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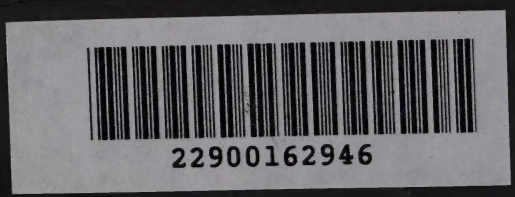
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Water Standards.

	T.S.	pts per 100,000 Albuminoids	Chlorine
Rain	3	.003	.2
Upland surface	10	.01	1.
Springs	28	.4	2.5
Deep wells	44	.5	5
Sea	3898.7	.003	1975.6
Sewage	72	none	10-11

Translation pts per 100,000

Free. ammonia	.005	.003	.001
Alb. <.005	.008	.01	.02 peaty.

Oxygen absorbed pts per 100,000

Good	Wanting	Suspicious	Bad
<.1	<.15	<.2	>.2

Translation pts per 100,000

Good H2O not > .2 org C.
> .02 N.

Sewage 2 of H = 6 org C.
0 = 2 N.

Malcolm Watson.
London. Oct '99

HANDBOOK OF HYGIENE

A HANDBOOK OF HYGIENE AND SANITARY SCIENCE

BY

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PREFACE

THE last Edition of this Handbook was for the most part rewritten and greatly enlarged, but so continuous and rapid is the advance of knowledge in the wide domain of Public Health and Practical Sanitation that it has again become necessary to rewrite large portions, as well as amend and carefully revise throughout. Although every effort has been made to eliminate and compress, in order to make room for new matter, the bulk of the volume is still further increased, both in respect to the size of the page and the number of pages. Several new engravings have also been introduced to illustrate the text, and more especially those parts of it which deal with water-supply, sanitary fittings, drainage, and hospitals.

Among the many alterations and additions which have been interpolated may be mentioned the following :—In the chapter on Food, a new section has been inserted dealing more fully with milk in relation to disease, and giving a summary of the typical and more recent milk-borne epidemics; while the question is discussed as to whether scarlatina or diphtheria can be placed in the same category with tuberculosis as genuine bovine diseases. Reference is also made to the later outbreaks of ptomaine or food-poisoning, and the investigations undertaken by the Local Government Board concerning the spread of cholera and

enteric fever through the agency of oysters and other kinds of shell-fish.

The chapters on Air, Ventilation, and Air Analysis have been carefully revised and brought up to date, and the chapter on Meteorology has been extended; while the chapters on Water, Water Analysis, and Water Impurities have been supplemented by new sections on water-supplies for villages and rural districts, water fittings, and the filtration and bacteriological purification of water. The *résumé* of typical epidemics of water-borne diseases, such as lead-poisoning, cholera, and enteric fever, has also been rearranged to include a brief summary of the more recent and noteworthy outbreaks which have been investigated.

The chapters on the removal and treatment of Sewage and House Refuse have been almost entirely rewritten, so as to present the latest improvements in sanitary fittings; house-drainage and sewerage; dry methods of conservancy, with special reference to the requirements of rural districts; and the disposal and cremation of house refuse. In addition to giving a brief review of the numerous chemical processes which have been tried, or are still in operation, for the treatment of sewage, special pains have been taken to summarise the latest developments of biological processes as illustrated by the "septic tank" and other systems, specially prepared filters, intermittent downward filtration, broad irrigation, and combined processes; while the methods best suited for small towns or villages, and isolated houses or groups of houses, have been described.

In the chapter on Soils and Localities, and their influence on health generally, the part played by filth-polluted soil as a breeding-ground for pathogenic organisms, as well as the latest results of bacteriological research in this direction, have been briefly discussed, and more particularly in respect to cholera, enteric fever, diphtheria, epidemic diarrhœa, and

phthisis. In the chapter on Dwellings, the directions concerning the mode of inspection of houses have been amplified, and a detailed description is given of the system of certification which is now being adopted in many health resorts for hotels, lodging-houses, and other dwellings. A short section has also been added on schools and school boarding-houses. The chapter on Hospitals contains particulars with regard to the most recent improvements in hospital construction; and, in respect to isolation hospitals, the latest Memorandum of the Local Government Board has been summarised, and the plans suggested by the Board have been outlined.

The chapter on Infectious and Parasitic Diseases has been prefaced by a review of the present position of bacteriology, more particularly in relation to infection, immunity, antirabic vaccination, and serum therapeutics; and if the opinions expressed throw grave doubts on the success of so-called bacteriological treatment, whether in the direction of protection or cure, it will, I hope, be conceded that they have not been formed hastily nor without the most open-minded and careful scrutiny. While I have all along held the profoundest belief in the efficacy of vaccination as a protective against small-pox, I have never been able to see that there is any real or legitimate analogy between these newer methods and Jenner's great discovery on which they are admittedly based; and I have made bold to question the inference that statistical results have in any measure established the success of Pasteur's antirabic vaccination as a remedy for hydrophobia, or of serum antitoxins as cures for diphtheria, tetanus, and other allied diseases. From the point of view of practical sanitation, I also venture to assert that the trend of microbial investigations has of late years threatened to ignore or minimise the influence of those conditions of environment without which many patho-

genic organisms are powerless for mischief, but on whose betterment or abatement the grand policy of prevention still mainly rests—a policy which has all along been so strenuously advocated by the Medical Department of the Local Government Board from the days of Sir John Simon down to those of its present chief, Sir Richard Thorne, and in this country has been attended with such pronounced and gratifying results. Admitting to the full the benefits which have accrued from bacteriological research, I feel therefore bound to contend that there should be some pause in the indiscriminate maiming and destruction of animal life with which it is inseparably associated, and, to say the least, the somewhat reckless experimentation on human life which its discoveries are believed to warrant, in order to institute a judicial and searching revision of the now widely extended relations of bacteriology to preventive and curative medicine, and frankly scrutinise the alleged successes of these novel methods of treatment. For it would almost seem as if the medical profession had well-nigh forgotten the lesson taught by the dismal failure of Koch's tuberculin, which was hailed as a panacea for phthisis with such general acceptance only a few years ago; and indeed there appears to be an increasingly large number of conscientious enthusiasts who are not only ever ready to welcome any new toxin or antitoxin elaborated by the bacteriologist, and tested on animals, but with a confidence, born surely of the largest hope, are forthwith prepared to adopt it as a specific for the prophylaxis or cure of human disease.

It is not without a grave sense of responsibility, and with no small amount of diffidence, that I have felt constrained to advance views in this chapter which, I am well aware, will be regarded as heterodox by large numbers of the profession; but I have endeavoured to sift the evidence and submit my conclusions with the strictest fairness, and

as fully as the limited space at my disposal would permit. In dealing with small-pox further on in the same chapter, I have, however, been at pains to summarise, from Dr. Bond's most valuable pamphlet, the leading facts of the late Gloucester epidemic, for the reason that they have established, more clearly than those connected with any previous epidemic, the tremendous risks which a community runs in neglecting vaccination, and the absolute certainty with which the disease may be stamped out by effective vaccination and revaccination. I have also made brief reference to the recent report of Sir Richard Thorne and Dr. Copeman on glycerinated calf-lymph, and quoted the conclusions of the Royal Commission on Vaccination. With regard to the new Vaccination Act, it is to be feared that the helpless conscience clause, and other concessions, will not win over either those who fail to see that all the obligations of citizenship in respect to the protection of the public health are necessarily based on compulsion, or those who, without reasoning for themselves, are influenced by the delusive propaganda of the Anti-Vaccination League. Moreover, it is highly probable that any failures or doubtful results associated with these newer methods of prophylaxis or cure which are based on Jenner's discovery, but to which, as I have endeavoured to show, they bear no legitimate analogy, will only serve to arouse still further distrust and opposition.

In the chapter on Prevention and Disinfection, notice has been taken of the newest disinfectants, appliances, and methods which have met with more or less general approval; while the suggestions as to practical disinfection and precautionary measures have been carefully revised, and supplemented in the Appendix by the Memoranda issued by the Local Government Board on disinfection and the closure of schools.

The chapter on Vital Statistics has been to a large extent rewritten, and in addition to explaining how estimates of

population are calculated, death-rates corrected, and life-tables for sanitary purposes constructed, free use has been made of the recently-issued Supplement to the Registrar-General's Report following the 1891 census, prepared by Dr. Tatham, with respect more especially to the newest life-tables, and the mortality statistics of occupations and trades.

The lengthy chapter on Sanitary Law and Official Duties, which appeared in the last Edition, has been replaced by two new chapters, one on Sanitary Law, and the other on Sanitary Officers and their Duties. In the former, an effort has been made to rearrange under appropriate headings as complete a digest of the portions of the numerous legislative enactments which concern the duties of sanitary officers in the different parts of the United Kingdom as the efficient discharge of such duties requires, together with a synopsis of all the more important model bye-laws issued by the Local Government Board of England. In addition to the Public Health Act, 1875, and the other supplementary Acts, which apply to England and Wales, parallel references are made to the Public Health (Ireland) Act, 1878, the Public Health (London) Act, 1891, and the still more complete Sanitary Code embodied in the Public Health (Scotland) Act, 1897. A digest has also been made under their respective headings of the several Sanitary Acts which apply to the whole of the United Kingdom, while the sanitary powers of County Councils and Parish Councils have been briefly detailed. Full reference is given to the enormous number of clauses of the numerous Acts dealt with; and though it became necessary to dissect many of the Acts, and distribute such portions of them as apply under the various headings, great care has been taken to maintain the continuity of the text, and also to elucidate it by explanatory remarks, so as to render such a complicated subject as clear and readable as possible.

The concluding chapter, on Sanitary Officers and their Duties, contains full information concerning the appointment of Medical Officers of Health, Surveyors, and Sanitary Inspectors in the several parts of the United Kingdom; the Regulations issued by the Local Government Board in respect to duties; and practical suggestions with regard to routine of duty, sources of information, reports, etc.

In the Appendix will be found several of the more important Memoranda issued by the Local Government Board; the General Order issued in 1896 with respect to Cholera, Yellow Fever, and Plague; and engineering and other useful data.

Although, as heretofore, I have avoided burdening the text with foot-notes, it will be seen that frequent reference is made to authorities, and I have once more to express my grateful obligations to Sir Richard Thorne for favouring me with copies of the most recent reports, memoranda, and general orders issued from the Medical Department of the Local Government Board. In other directions, I have spared no efforts to collect reliable information from all the latest approved sources, and have honestly striven to make this Edition still more worthy of the favourable reception which has all along been accorded to the work as a reliable Handbook of the most recent advances in Public Hygiene, Sanitation, and Sanitary Law. I hope, therefore, that it will still be welcomed as a text-book by students, while I have constantly kept in view the main purpose for which it was first written, namely, that it should be a guide to medical officers of health and other sanitary officers, as well as a practical work of reference for medical practitioners generally and all who are interested in sanitary progress.

7 Avon Place, Warwick,
September 1898.

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CHAPTER I.—INTRODUCTORY

PUBLIC HEALTH AND PREVENTABLE DISEASE

PUBLIC HYGIENE may be defined as that branch of social science which concerns the physical condition of communities. It embraces a consideration of the various influences operating upon society, whether for its material good or its actual deterioration, with the view of extending the former, and preventing or ameliorating, as far as possible, the effects of the latter. It involves the enactment of laws by which the safety of the whole may be protected against the errors of a part, and, above all, it aims at the prevention of disease by the removal of its avoidable causes. In a wide sense, therefore, the science of public hygiene enlists the services of the people themselves in continuous efforts at self-improvement; of the teachers of the people, to inculcate the best rules of life and action; of physicians, in preventing as well as curing disease; and of lawgivers, to legalise and enforce measures of health-preservation. But while it is the special province of the medical profession, as guardians of the public health, to study the causes of physical deterioration and disease, and to point out how far these causes may be controlled or averted, the general well-being of the people must mainly depend on their own exertions and self-restraint. Sanitary improvements in man's material surroundings will not compensate for social transgressions against laws of morality; for public virtue is essential to public health, and both to national prosperity.

The time, however, has gone by when people can be dragooned into cleanliness or be made virtuous by police regulations; and hence it is that the most thoughtful among practical reformers of the present day base their hopes of sanitary progress on the education of the masses as the real groundwork of national health. The people must be taught that good conduct, personal cleanliness, and the avoidance of all excesses, are the first principles of health-preservation; that mental and physical training must go hand in hand in the rearing and guidance of youth; and that morality does not consist so much in a blind observance of the formulæ of empty creeds as in a hearty submission to precepts of health. Nor is this all. They must be interested systematically in the general policy of prevention, and thus become more intimately acquainted with the social and material causes by which sanitary progress is impeded. Unless a knowledge of these fundamental principles of hygiene be widely disseminated amongst them, it is in vain to expect that legislative enactments, however well devised, will succeed in raising the standard of public health to any considerable extent. But there are hopeful signs of progress even in this direction. The teaching of physiology and the laws of health, which is being gradually introduced into many schools, will doubtless be productive of much good amongst the rising generation; while the large share of attention which the discussion of sanitary questions is now receiving in the public press is the best evidence of the steady growth of intelligent conviction as regards all matters affecting the preservation of health and the prevention of disease.

Taking, then, this wide view of the scope of public hygiene, it should prove alike interesting and useful if, by way of introduction, we take a brief historical retrospect of its various phases, and more particularly of its progress during recent years. For sanitary science, in the broad sense of the term, is knit up with the life-history of every nation, and enters largely into the history of civilisation.

It figures prominently in the Mosaic code of the Jewish race, and its instructions and preventive measures, as exemplified in that code, have accounted largely for the greater comparative longevity of the Jews, for their extraordinary immunity from the recurring epidemics of the Middle Ages, and for the widespread, though silent, influence which they have long exercised, and still exercise to the present day.

Or let us glance at those grand old Greeks who have left us such a rich store of philosophy, literature, and art. It is true that though their sanitary code, propounded by Lycurgus, was severe and cruel, yet the means which they adopted in the care and cultivation of their bodily physique, and the development of their intellectual faculties made them the civilisers of the old world and the exemplars of modern times. But the Greeks, with all their wisdom and physical culture, knew very little of the causes of disease as it affects communities, and they accepted the terrible epidemics with which they were visited as manifestations of offended deities, or, at the best, as afflictions which could neither be avoided nor prevented. Their decline and fall as a nation were due to the luxury into which they lapsed, and the lax morality which ultimately became their ruin and opprobrium.

Referring, now, to the Romans, the other powerful nation of antiquity, we find that though they contributed but little to sanitary science, they have left some wonderful examples of sanitary engineering on a large scale. Their *Cloaca Maxima*, for example, and the aqueduct for conveying water from the hillsides to Rome, a distance of some thirty miles, were works of such stupendous magnitude that they have seldom been equalled or surpassed even at the present day. But the Roman Empire, like that of the Greeks, was destined to pass away, and those who have studied the social causes of its decay, attribute its ultimate decline, in no small degree, to the epidemics which devastated the population in the early centuries of the Christian era, and often followed in the wake of war.

We next pass on to what have been termed the dark or Middle Ages, and to the health history of England. The accounts at first are very meagre, but when they become more numerous and reliable they tell us of frequent visitations of plague, pestilence, and famine—mixed up with stories, strange and incredible, of armies fighting in the air, showers of blood, terrible earthquakes, and the like—all of them showing how deep-rooted was the belief in the supernatural as regards epidemic disease and its causes. If, however, we look at the habits and habitations of our forefathers, we have no difficulty in accounting for the fearful mortality which prevailed amongst them. Personal cleanliness was utterly neglected. Clothing was immoderately thick and warm, and was seldom changed night or day. The diet was coarse, consisting chiefly of flesh meats highly seasoned. Strong wine or ale was drunk early in the morning, and often far into the night; in short, gluttony and intemperance were prominent characteristics of the sturdy fighting Briton of mediæval times.

Then, as regards his dwelling, we find that the towns and villages were composed for the most part of hovels, with mud walls and thatched roofs. "The floors of the houses," to quote from a well-known letter of the learned Erasmus, "were generally made with loam strewn with rushes, constantly put on fresh without removing the old, lying there in some cases for twenty years, concealing fish-bones, broken victuals, and other filth," so that one can quite credit him when he says further, "If even twenty years ago I had entered into a chamber which had been uninhabited for some months, I was immediately seized with fever." The streets were unpaved, generally covered with clay and rushes, concealing all sorts of abominations; moreover, they were dark, narrow, and tortuous, and without sewers or drains. The rural population, on the other hand, were scattered in slight hovels over wild woods, dreary wastes, and undrained marshes, so that ague and rheumatism were always rife amongst them; and in times of scarcity, which were common

enough, they were sure to suffer from famine. Add to all this, that there was constant fighting of some sort going on. Kings were warring against powerful subjects or foreign foes. Cities and towns were walled-in fortresses; and the roads were beset with marauders and highwaymen. Dogberries watched the streets but did not ward them, bravoes stabbed, burglars were plentiful, and amongst all classes life was held very cheap. Those, indeed, were days in which Darwin's doctrine of survival of the fittest was exemplified to the fullest extent; the weakly went to the wall, and left, on the whole, only those of iron constitutions to perpetuate a brave, hardy, and pushing race, which increased in numbers slowly, if at all, for centuries.

We thus see that conditions inimical to health were abundant everywhere. The walled-in cities were highly favourable to overcrowding and stagnant air; the large armies, which were in constant motion, conduced greatly to the spread of epidemic disease; while personal uncleanliness and intemperate habits made the people ready victims of disorders of all kinds. It is not surprising, therefore, that fevers and devastating epidemics were prevalent; and as instances in point, the following may be given:—For example, in the twelfth century, there were fifteen widespread epidemics and many famines; in the thirteenth century, twenty epidemics and nineteen famines; and in the early part of the fourteenth century there were eight epidemics and more famines. And these epidemics, it should be remembered, were not local outbreaks appearing only here and there, but they spread so far and wide that each and all of them were regarded as visitations of national disaster.

And now we come to the fatal year of 1348, when the Black Death or Great Mortality, as it was called, first appeared in England. It is believed to have been an aggravated outbreak of the Oriental Plague, which was then devastating Europe as it had devastated the East. It was an eminently contagious disease—imported, no doubt, in the first instance; but when once it gained a footing on our

shores, it spread with such terrible rapidity, that within a few months almost every town and village throughout the country had been attacked, and in some places only a fourth part of the inhabitants were left alive. In London alone 100,000 fell victims to the disease, and 50,000 corpses were interred in one burial-ground, heaped together, layer upon layer, in large pits. Throughout Europe it has been estimated that twenty-five millions, or a fourth part of the entire population, were swept away. Imagination fails to realise the misery and horrors of the time. The sick died untended, charity was dead, and hope extinguished—everywhere there was terror and black despair.

Without noticing other epidemics which followed the epoch of the Black Death, the next great pestilence which ravaged the country, and known as the Sweating Sickness, broke out in 1485. Unlike the Black Death and the Oriental Plague, which reappeared in the sixteenth and seventeenth centuries, it did not originate in a foreign country to be conveyed by infection to our own shores, but it sprang into existence in this, and was no doubt generated and propagated by the insanitary conditions of dwellings and towns, and the filthy and intemperate habits of the people. For the most part it attacked robust middle-aged adults, men fond of good living, and those amongst the poorer classes who were described as "idle persons, good ale drinkers, and tavern haunters." Its onset was quick and its termination rapid, the victim generally dying within twenty-four hours; while the mortality was so great that in many parts of the country half of the male adult population were swept away. During the latter part of the fifteenth century, and the first half of the sixteenth, this pestilence reappeared no less than five times, its last visitation having occurred in 1551. Yet it must not be forgotten that this sixteenth century, with its long list of ravaging diseases, gave us, nevertheless, the heroes of the Elizabethan age, our triumph over Spain, and our English Reformation. But progress in sanitary defence was slow, tedious, and tentative. Indeed, the extraordinary vitality

and indomitable pluck of the English race would almost appear to have been the sole defences against national decay and disaster, for during long years to come there was but little improvement in the homes or habits of the people. It was not until the Plague, which was the next great pestilence after the Sweating Sickness, had repeatedly devastated the country, and the great fire which swept away the crowded and filthy homes of London in 1666 occurred, that people began to appreciate, though in a faint and glimmering way, the principles of prevention. The Plague died out with the fire, but small-pox, jail fever, malignant sore throat, ague, scurvy, and other controllable diseases, still continued to contribute to the excessive mortality of the seventeenth century.

But now we come to the dawn of a better day. The gradual improvements in agriculture, manufactures, and commerce were adding steadily to the comforts of life. Food was becoming more plentiful, and the diet less coarse. Vegetables, and more especially the potato, were becoming much more generally used; fresh meat was taking the place of salted meat, which had hitherto constituted such a large part of the English dietary; while tea and coffee were to some extent replacing the strong ale and ardent spirits which had formerly proved such a baneful source of disease. People, too, were beginning to recognise the value of cleanliness of person and home. The introduction of soap and soda made washing easier, and cotton and linen articles of clothing were gradually coming into more general use. Thus far, then, it may be said that the seventeenth century, although characterised by no great advance in sanitary progress, witnessed, nevertheless, some considerable improvements of an incidental and indirect kind. The gradual emancipation from the thraldom of filth had begun, and precautionary measures against the spread of disease in the form of a rough-and-ready system of quarantine were here and there attempted. But the great purifier of the century was the memorable fire of London, which consumed everything from the Tower to Temple Bar, destroying 81 out of

the 97 parishes within the city boundaries, and two of the parishes outside the walls. The old wooden houses with their overhanging stories, and the huge sign-boards swinging across the narrow, winding, filthy, unpaved, streets, were swept away; and though the model city which Sir Christopher Wren had planned was not destined to be realised, better houses were constructed, wider streets laid out, and sanitary conditions in other respects were considerably improved.

Coming now to the health history of the eighteenth century, we find that three terrible scourges, namely, the Black Death, the Sweating Sickness, and the Plague, have finally disappeared from the bills of mortality. And their disappearance, as we have seen, is not to be attributed to any conscious or well-sustained efforts in the way of prevention, but to the silent influence of the onward progress of civilisation. We now, however, enter upon an era in which observation and induction begin to play a part in the prevention of human suffering, when the physical causes of disease receive fuller appreciation, and when it is at last recognised that these causes can be inquired into and dealt with in a scientific manner. It is true that the workers were few, but the results of their labours have been fraught with untold blessings to humanity. Foremost amongst these pioneers of sanitary science, we find the honoured names of Captain Cook, John Howard, and the immortal Dr. Jenner; and now let us glance briefly at the good work which they accomplished.

Captain Cook's name is associated with the suppression of the once prevalent disease—scurvy; a disease which, up to the latter half of the eighteenth century, decimated our armies and fleets, and often proved terribly fatal amongst the civil population. It is a disease easily recognised and well defined; fostered, as many other diseases are, by insanitary conditions; but its real cause is insufficient food, or a diet from which vegetables and fruits have been excluded, and therefore its prevention or cure depends upon a proper supply of vegetable food or vegetable juices. It is true that all this had been known or surmised long anterior to the period in

question; but it was reserved for Captain Cook, in his first voyage of discovery round the world, from 1772 to 1775, to prove beyond a doubt that the disease could be banished from every ship's crew, and that it could be entirely eradicated on land and sea. Hitherto it had been a cause of great mortality amongst seamen; and, to quote one instance out of many, in Anson's famous expedition some thirty years previous to that of Captain Cook, out of a total number of 900 hands 600 died before the expedition returned, and chiefly from scurvy. During Captain Cook's three years' voyage, on the other hand, there were only four deaths, namely, three from accident and one from consumption, out of a total number of 118 men. Captain Cook thus earned for himself a foremost place amongst the sanitary reformers of the eighteenth century; but the nation took years to learn the lesson which he taught, and many more lives had to be sacrificed before it became compulsory that lime-juice should form a part of the commissariat of every sea-going vessel.

The next great reformer deserving of special notice was the great and good John Howard. His name, so widely known, is associated with the prevention of a fatal disease, then called the jail-fever, which was constantly breaking out in prisons all over the country, had often invaded the courts of law, and made several assizes memorable as the Black Assizes, and which was continually spreading by means of infection, through the agency of discharged prisoners and debtors, amongst all classes of the community. The disease has long since been recognised to be the same as typhus fever, and John Howard lived the life of an apostle and died a martyr in proving that it is a disease which is essentially due to filth and overcrowding. Without enlarging on the incidents of his self-sacrificing labours, the outcome of them is simply this—that for years back the prisons of this country have been proved by the most rigid statistics to be far healthier than our homes, and that so-called preventable disease of any kind is of such rare occurrence within their walls, that when any isolated cases do appear

they at once give rise to surprise, and are sure to call for inquiry.

The next great sanitary triumph of the eighteenth century calling for special notice was the discovery of vaccination. That most hideous and terribly fatal disease, small-pox, had long been a terror and scourge to all classes of the community here and abroad, and, after the disappearance of the Plague, became the severest epidemic of the country. The introduction of the practice of inoculation at the instance of Lady Mary Wortley Montagu, the wife of the English Ambassador at Constantinople, which took place somewhere about the year 1720, while it modified the severity of the disease, assisted rather than otherwise its spread. But whether this was so or not, we find from the bills of mortality of the time that during the ten years 1771 to 1781, small-pox was the cause of 100 out of every 1000 deaths in London, and there is reason to believe it was quite as fatal in other parts of the country. The practice of vaccination, Jenner's grand discovery, was commenced in the year 1796, and although it was several years afterwards before it became general, its value as a preventive measure was not long in declaring itself in a steadily declining mortality. Thus, according to well-authenticated returns, while the mortality was 88 per 1000 deaths in the last ten years of the eighteenth century, it has fallen progressively from 64 to 11 per 1000 deaths during the first six decades of the present century. And if we have still recurrent outbreaks of the disease, it is because there are thousands of people living at the present day who never have been protected by vaccination, and many thousands more who have been imperfectly vaccinated. For it should be remembered that it was not till 1840 that we had any vaccination laws at all; not till 1853 that vaccination was provided gratuitously for the poor; and not till 1867 that vaccination was made compulsory amongst children generally. We may therefore expect occasional outbreaks for years to come, especially in view of the increasing number of anti-vaccinists; but that

the disease can and will be finally eradicated, the belief is as deep-rooted and strong in the minds of medical men and of the educated public of the present day as it was in the stout, brave heart of Edward Jenner.

In addition to these great sanitary triumphs of the eighteenth century there were others, such as improvements in ventilation and better house accommodation, which were also contributing their share in lessening the general death-rate, and especially in the reduction of fevers of all kinds. Diseases amongst infants and young children were much less fatal at the close than at the beginning of the century, while the labours of John Howard were beginning to tell on the home habits of the people, as they had already told on the vast improvement which had been effected in the sanitary condition of prisons and jails. The health of our soldiers and sailors was much better cared for, and the sickness and mortality greatly reduced. Altogether the progress made in the actual prevention of disease was very considerable; and accordingly we find from the bills of mortality that the death-rate of the city of London, which in the seventeenth century was over 80 per 1000, had been reduced to 50 per 1000, and for years back it has averaged only a little over 20 per 1000.

Coming now to the beginning of the present century, we find the country engaged in that long, fierce struggle with France which culminated in the victory of Waterloo; yet, in spite of the constant drain in men and money, the population kept steadily increasing, and the public health slowly improving. But outside London there were no large towns teeming with overgrown populations—none contained so many as 100,000 inhabitants, and only five exceeded 50,000. By and by, however, there came a sudden and unprecedented change in the social history of the country. The discovery of steam-power opened up new sources of industry of almost unlimited extent and variety. Commerce flourished as it had never flourished before; wealth accumulated; work became plentiful; living became easier; early marriages were encouraged; and the rapid increase of

population begun then has continued ever since. The population of England and Wales, which, in round numbers, was only ten millions in 1810, had increased to over fifteen millions in 1838; and at the present day it amounts to over thirty millions. And this enormous increase, it should be remembered, has taken place almost exclusively in already populous towns, or at centres of industry which speedily became populous. But under what conditions? For the most part in the dust and din of factories; the vitiated air of mines; the stifling atmosphere of workshops; the bustle of busy warehouses; and when the day's work was done, in overcrowded houses or underground cellars, heaped together in filthy, narrow, and unventilated streets, or reeking back slums. Even in the construction of better-class houses the veriest rudiments of sanitation were neglected, because they were still but little understood and less appreciated. Instead of municipal control there was general apathy. Sewers had to be constructed, but they were of the worst possible description, uneven, leaky, unventilated, and incapable of being flushed, while the house drains leading into them were quite as faulty and imperfect. Scavenging was neglected, filth accumulated everywhere, cess-pits multiplied, and wells became polluted. But why fill up the disgusting details of the picture? The mischief was done, and in spite of recent improvements and legislative enactments, it will take years of steady, earnest, sanitary work, and millions of money to undo it. The money, no doubt, will be forthcoming, and the cleansing of the Augean stables may be accomplished in time; but the squalor, the misery, the disease, the physical deterioration, and the moral degradation engendered, have imposed a load of vitiated heritage which will tell on generations yet unborn, and which at the present day is crushing thousands of children into an early grave.

Meanwhile the Legislature had done nothing, or next to nothing, to mitigate the terrible evils which were fast accumulating. With the exception of the Factory Act of 1833, and the Poor Law Amendment Act of the following

year, no public measures of general importance had been attempted, and even these were hap-hazard and tentative. It is true that here and there local Acts had been applied for and granted by Parliament to empower town authorities to provide water-supply and drainage, but it was not till those wonderful series of returns of the Registrar-General, and the masterly reports of the late Dr. William Farr, began to be published, that public attention became thoroughly aroused. At last, thanks to the incessant labours of Sir Edwin Chadwick, Dr. William Farr, Dr. Southwood Smith, Dr. Guy, and other pioneers of sanitary progress, all of whom have passed away, the Health of Towns Commission was appointed, and their first report appeared in 1844,—a report in which the relations of cause and effect, as applied to disease, were made so glaring and manifest, that among the intelligent portions of the community there arose a loud cry for legislative interference. Things are still bad enough in the present day, but few can form any adequate conception of the deplorable sanitary condition of the country when that report was published. From every large town to which the long list of queries was sent, there came, with but little variation, the same terrible series of replies—bad drainage, polluted water, unhealthy houses, overcrowding, filth everywhere; and, as a consequence, an excessive death-rate, with fever and filth-diseases of every description adding enormously to the death-roll. But so powerful were vested interests, and so strong the opposition to interfere with the liberty of the subject or of corporate bodies, that it was not till the country was threatened with a second visitation of cholera as severe as the epidemic of 1831, that Parliament became alarmed and passed the Public Health Act of 1848. Under this Act the General Board of Health was constituted, with a staff of inspectors who were empowered to hold public inquiries and report on the sanitary condition of towns which, according to the returns of the Registrar-General, showed an excessive rate of mortality. The Act itself was eventually adopted or enforced in a great many

towns throughout the country; but as it was of a permissive nature, like many of the sanitary Acts which followed it, the beneficial results which might have been expected to accrue from it were long in appearing, and were by no means general. Nevertheless, it originated an era of active sanitary improvement in most of our large towns, and it merits special notice as the first outspoken recognition on the part of the Legislature that the health of the State concerns the statesman. By enabling town authorities to borrow money and spread the expense of public works over a number of years, it removed one of the greatest obstacles to sanitation, and, as a consequence, extensive schemes of sewerage and water-supply were soon undertaken in many parts of the country. But, unfortunately, the engineers of those days largely shared the general ignorance of sanitary principles which then prevailed. Sewers were badly constructed, insufficiently ventilated, and unflushed; many of them, in fact, were elongated cess-pools, and the sewage itself, collected at one or more outfalls, was discharged into the nearest stream, thereby creating a general befoulment of our rivers, which, in spite of numerous injunctions, became so serious as to call for a special Act, which was passed in 1876 under the title of the Rivers Pollution Act.

Among other Acts which followed the Public Health Act of 1848 may be mentioned the Common Lodging-Houses Act of 1851, the Labouring Classes Lodging-Houses Act of the following year, the Metropolis Management Act of 1855, and the Nuisances Removal Act and the Diseases Prevention Act, both of the same year. But during the interim, the nation had been learning another terrible lesson in sanitation. The horrors of the Crimean war, engendered by a faulty commissariat, an utter neglect of scavenging and cleanliness, and an incredible disregard of the most rudimentary laws of health, at last aroused and excited the public mind to the point of indignation, and so in 1857 was instituted the Royal Commission on the Health of the Army. Their report, which is still of the greatest value, was soon followed by the reports of the Barrack and

Hospital Commission, and of the Commission on the Health of the Army in India, all of which demonstrated in the most complete manner that the sick-rate and death-rate of the army were culpably excessive; while the adoption of their recommendations, under the able teaching of the late lamented Dr. Parkes, afforded such conclusive proofs of the grand policy of prevention, that a stimulus to sanitary reform began to permeate the more intelligent classes among the general community which has continued to increase ever since.

The powers of the General Board of Health were transferred by Act of Parliament to the Privy Council in 1858, and in the same year the Local Government Board Act was passed, which consolidated to some extent the previous Sanitary Acts which were in force. The appointment of Mr., now Sir John, Simon as medical officer to the Privy Council, with his able staff of medical inspectors, inaugurated a new era in civil life. The material causes of disease were investigated with a minuteness and completeness of detail which could not fail to influence the most sceptical, and the series of reports, in which these investigations are embodied and commented on, have become the classics of sanitary literature. To any one who takes the trouble to read these reports, it becomes at once apparent that whatever of purely beneficial sanitary legislation, which has subsequently come into force, has all along been largely indebted to Sir John Simon's foresight and advocacy, based on the inquiries of such able coadjutors as Seaton, Greenhow, Buchanan, Hunter, Thorne Thorne, Netten Radcliffe, Ballard, and others. Many of these inquiries will be specially alluded to in various parts of this work, but this brief historical sketch would be incomplete without referring to two discoveries in sanitary science which have already resulted in a vast amount of good, and destined to be of still greater benefit to the nation;—namely Dr. Snow's researches with regard to the etiology of cholera (see Chap. IX.) and the differentiation between typhus and typhoid fever as regards causation and symptoms, and this last deserves special notice.

About the year 1848, when fever was plentiful enough in all our large towns, and did not spare country villages, the late Dr. Stewart, so well known for his contributions to sanitary literature, Sir William Jenner, and a few other earnest workers in hospital wards, began to observe that among the numerous cases of so-called typhus which came under their care there were many which presented symptoms of a more or less uniform character, but differing in many respects from those which characterised typhus fever. These symptoms soon came to be recognised as those of typhoid or enteric fever, and subsequent inquiries have so clearly established the causes and mode of propagation of this fever, that it is now regarded as a disease which is entirely preventable, and one which we have every reason to believe will eventually be as completely banished from our midst as the ague, which was once so common and now so rare. But it was urged by many, when this disease came to be talked about and written about, and was frequently found to be due to the entrance of sewer-air into houses, that in sewering a town public authorities only increased the danger, and that the money expended was worse than wasted. It is true that at first there was some show of foundation for this belief, but it has long since been made clear that any outbreaks of the disease which have been traced to sewer emanations were due not to the system itself, but to faulty sanitary engineering. Indeed, in the celebrated report of the late Sir George Buchanan, who was the inspector appointed to visit a large number of towns and make special inquiry into this subject, there was no point more clearly established than the remarkable reduction which had taken place in almost all the towns where a system of sewerage had been carried out.

Without referring to other important inquiries, such as those relating to unwholesome trades and occupations, food-adulterations, polluted water-supply, overcrowding and unhealthy house-accommodation, milk-contamination, and the widespread agency of filth in the causation of disease, we may note in passing the principal legislative measures

which have recently been enacted to cope with these evils. And among these may be mentioned the Adulteration of Food and Drink Act of 1860; Amendments of the Factory Acts; the Sanitary Act of 1866; the Local Government Board Act of 1871, which vested in one central board the powers previously exercised by the Poor Law Board and the Privy Council; and the Public Health Act of 1872. This last Act divided the country into urban and rural sanitary districts, and necessitated the appointment of medical officers of health and sanitary inspectors; while the Adulteration of Food Act, which was passed in the same year, authorised the appointment of public analysts. Then followed the Public Health Act of 1875, which consolidated the previously existing sanitary Acts; and in the same year were passed an amended Adulteration Bill, and the Artisans' and Labourers' Dwellings Act, intended to sweep away the rookeries in our large towns. The Rivers Pollution Act followed in 1876, the Canal Boats Act in 1877, the Public Health (Water) Act in 1878, while several other Acts have since been passed of special importance, among which may be mentioned the Local Government Act of 1888, the Infectious Diseases (Notification) Act, 1889, and the Housing of the Working Classes Act, 1890. Reserving the consideration of the strictly medical aspects of these and various other Acts for the concluding chapter, it may be remarked in passing that, partly owing to the permissive nature of sanitary legislation, partly to the conflicting opinions and want of harmony which it is well known for a long time hampered the policy of the Local Government Board, and partly to the supineness of Local Authorities and their aversion to centralisation and Governmental interference, sanitary reform, in spite of all the obligations which the Legislature has imposed, and the measures to carry them out which it has provided, has made but little advance in many parts of the country. It is true that in numerous other localities there is abundant evidence of sound sanitary progress, but so long as the Public Health Service is allowed to continue in its present chaotic

condition, so long will there be loopholes for the evasion of duty on the part of sanitary authorities, and inducements to remissness on the part of their officers.

This, however, by the way. Let us now consider for a moment the vast amount of preventable disease with which sanitary science and sanitary legislation had to combat at the date of the passing of the Public Health Act, 1872. It was then estimated by Sir John Simon "That the deaths which occur in this country are fully a third more numerous than they would be if our existing knowledge of the chief causes of diseases were reasonably well applied throughout the country; that of deaths, which in this sense may be called preventable, the average yearly number in England and Wales is about 120,000; and that of the 120,000 cases of preventable suffering which thus in every year attain their final place in the death-register, each unit represents a larger or smaller group of other cases in which preventable disease, not ending in death, though often of far-reaching ill effects on life, has been suffered."

That this estimate of the number of preventable deaths which occurred annually throughout the country up to the passing of the Public Health Act, 1872, was by no means excessive has since received ample verification in the reports of the Registrar-General. Thus, the average death-rate during the ten years 1861-70 was 22·42 per 1000; during the ten years 1871-80, it had fallen to 21·27; while during the ten years 1881-90, it was only 19·08 per 1000; and this last rate, when compared with that which prevailed during the decade 1861-70 represents alone an average annual saving of about 90,000 lives. At the close of the last decade, therefore, the estimate made by Sir John Simon twenty-five years ago, was being rapidly approached, and indeed, in some years since, it has been considerably exceeded.

Apart, however, from the reduction of the general death-rate, it is still more satisfactory to find that the mean annual death-rate from the seven principal zymotic diseases, which had been 4·11 and 3·36 per 1000 respectively in

the two decades 1861-70 and 1871-80, did not exceed 2·34 in the last decennium 1881-90 ; while the death-rate from fever alone, during the same period, did not exceed 0·23 per 1000, whereas in the two previous decades it was equal to 0·88 and 0·48 respectively. This remarkable reduction in the death-rate from fever, mostly enteric, affords the strongest possible evidence of the beneficial results which follow in the wake of improved sanitation. But though all this is very gratifying, the wide differences which are exhibited in the returns of the Registrar-General, as regards the rates of mortality of different towns and districts, prove beyond doubt that influences inimical to life continue to prevail to a far greater extent in some parts of the country than in others ; while a closer analysis of the death-register demonstrates still more clearly that this excess of mortality is for the most part due to diseases which in other ways are known to be preventable, and which detailed medical inspections in various localities have proved to be dependent upon causes which are not only removable, but whose very existence constitutes an offence against sanitary law. These causes have been grouped by Sir John Simon into two great classes, namely, local conditions of filth and nuisance polluting air and water, and reckless disseminations of contagion ; and as regards both these wide fields of disease-causation, the various sanitary enactments which have been passed from time to time have conferred extensive powers on sanitary authorities throughout the country to remove the former, and see that preventive checks are fully and fairly carried out with regard to the latter.

But in order to carry on this combat against preventable disease to a successful issue, we want a thoroughly organised Public Health Service, with efficiently trained health officers, surveyors, and sanitary inspectors, all of them holding permanent appointments under the control of the Local Government Board and the newly-constituted County Councils. We also want hospital accommodation for the isolation of cases of infectious disease, not only in towns

but to be available for the more scattered populations of rural districts. We want a wholesale demolition and reconstruction of the miserable homes of multitudes of the working classes; and we want, moreover, what is still very hard to get, the active and intelligent co-operation of the people themselves, not only in safe guarding against filth and its consequences, but in checking the spread of dangerous infectious disease.

CHAPTER II.—FOOD

Section I.—Functions and Constituents of Food

Without entering into a discussion of the various chemico-physical changes which food undergoes in the living body, it may be broadly asserted that its ultimate destiny is the development of heat and other modes of motion, which together constitute the physiological phenomena of animal life. The potential energy with which the food is stored becomes converted into actual or dynamic energy, and is manifested in the body as heat, constructive power, nervo-muscular action, mechanical motion, and the like. But as food also supplies the materials which are requisite for the development and maintenance of the living fabric, as well as for the display of its various kinds of active energy, it may be inferred that inorganic and organic substances are both necessary. The organic alone are oxidisable, or capable of generating force; while the inorganic, though not oxidisable, are essential to the metamorphosis of organic matter which takes place in the animal economy.

The organic constituents of food are generally divided into nitrogenous, fatty, and saccharine compounds; and the inorganic into water and saline matters. Both classes of constituents are present in all ordinary articles of diet, whether they be derived from the animal or vegetable kingdom.

1. *Functions of the Nitrogenous Constituents or Albuminates.*—The nitrogenous constituents consist of albumen in its various forms, fibrin, myosin or muscle-fibrine, casein, gluten, legumin, and other allied substances,

such as gelatine, ossein, and chondrin. The chemical composition of the former group of true albumens is remarkably uniform, and in 100 parts is approximately represented as follows:—nitrogen, 16 parts; carbon, 54 parts; oxygen, 22 parts; hydrogen, 7 parts; and sulphur, 1 part: the proportion of nitrogen to carbon being nearly as 2 to 7. By the action mainly of the gastric juice they are converted first into albumoses and then into soluble peptones in the process of digestion, and as these are highly diffusible they are readily absorbed into the blood and lymph streams through the inner coats of the alimentary canal. They can also replace each other in nutrition, whether they are derived from animal or vegetable foods, the only difference being that those of animal origin are more rapidly digested than the vegetable albumens. The allied albumens or proteids belonging to the gelatine group are much less nutritious, and cannot probably be converted into nitrogenous tissue although they are easily oxidised in the blood, and are used in the form of jellies. They contain a larger amount of nitrogen than the true albumens, the proportion to carbon being as 2 to $5\frac{1}{2}$.

Up to a comparatively recent period it was believed that nitrogenous constituents must first be converted into tissue before their dynamical energy can be elicited; in other words, that muscular force is entirely dependent on the metamorphosis of muscular tissue, and that urea, being the product of the change, ought to be regarded as a measure of the force. This was the doctrine taught by the late Professor Liebig, and it was generally accepted by physiologists until Drs. Fick and Wislicenus of Zurich published their famous experiments connected with their ascent of the Faulhorn. While these experiments proved that a non-nitrogenous diet will sustain the body during severe exercise for a short period, and without any notable increase in the amount of urea, the still more recent researches of Dr. Pavy in the case of Mr. Weston, so well remembered for his pedestrian feats, appear to indicate that at the commencement of a prolonged muscular effort, the nitrogen excreted

is considerably increased, and that subsequently it will vary pretty much according to the amount contained in the food consumed from day to day.

Judging from these and other experiments, it would therefore appear that, although the main functions of the nitrogenous constituents of food are the construction and repair of the tissues, and the formation of the digestive and other fluids of the body, they exercise other important functions of a regulative and dynamic nature not well defined. There is no doubt that a certain portion of them is directly decomposed in the blood, and so far they contribute to the maintenance of animal heat and the development of dynamic energy; but the experiments of Pettenkofer and Voit also tend to show that the nitrogenous substances composing the tissues determine the oxidation of the other constituents, or, in other words, that no manifestation of force is possible without their participation in the process.

2. *Functions of the Fatty Constituents or Hydrocarbons.*—All ordinary fats may be regarded as combinations of glycerine with fatty acids, such as oleic, stearic, and palmitic, acid. They do not contain any nitrogen, and may be generally represented by the formula $C_{10}H_{18}O$, the portion of oxygen in them being insufficient to combine with the hydrogen to form water. In the process of digestion they are emulsified by the pancreatic juice and bile, and are thus rendered capable of absorption by the lacteal vessels, while a small portion is no doubt saponified. The fact that food containing a large proportion of fatty ingredients is invariably used by the inhabitants of cold countries, indicates that these constituents play an important part in the maintenance of animal heat. Indeed, it has been proved by experiment that the respiratory or heat-producing powers of fat are twice and a half as great as those of the carbo-hydrates, such as starch or sugar. Fat also takes an active share in the conversion of food into tissue, and aids the removal of effete products from the system. The experiments already alluded to likewise show

that its oxidation in the blood generates to a great extent the force which is rendered apparent in locomotion or manual labour. Further, its distribution in the tissues gives rotundity to the form, serves to retain animal heat by its non-conducting properties, and greatly facilitates the working of the various parts of the living machine by lessening friction and preventing jarring by its elasticity.

3. *Functions of the Saccharine Constituents or Carbo-hydrates.*—These constituents comprise cane-sugar, glucose, sugar of milk, and starch. The starch contained in the various cereals and other vegetable foods, such as potatoes, is represented by the formula $C_6 H_{10} O_5$. In the process of digestion, and under the influence of the saliva and pancreatic juice, the starches are converted into grape-sugar, $C_6 H_{12} O_6$, by taking up an atom of water. This is absorbed into the blood and carried by the portal vein to the liver, where it is deposited as glycogen, and subsequently supplied to the system as required, where it becomes oxidised and converted into water and carbonic acid. Like the fatty constituents, the carbo-hydrates are directly subservient to the maintenance of animal heat and the production of animal force. They are capable of being converted into fat in the system, and are largely concerned in carrying on the digestion of nitrogenous substances, and in maintaining the proper reaction of the various bodily fluids.

4. *Functions of Water and Saline Matters.*—The principal functions of water in the animal economy are—the solution and conveyance of food to different parts of the system, the removal of effete products, the lubrication of the tissues, the equalising of the body temperature by evaporation, and the regulation of the chemical changes which take place in the processes of nutrition and decay. Saline matters, on the other hand, are the chief media for the transference of the organic constituents throughout the body, and are largely concerned in the consolidation of the tissues. The chlorides, represented by chloride of sodium or common salt, keep in solution the cells of the blood and

other fluids and are the source of the hydrochloric acid of the gastric juice; while the phosphates of lime, potash, and magnesia contribute largely to the formation of bone, and iron forms an important part of the hæmoglobin of the blood.

The functions of what are called the accessories of food, such as beverages, stimulants, etc., are still matters of speculation. Vegetable acids prevent impoverishment of the blood, and are the best correctives against scurvy. The principal among them are tartaric, citric, malic, and acetic, acids, and in the process of digestion they form carbonates which greatly assist in preserving the alkalinity of the blood and other fluids.

That all these four classes of constituents should be present in a well-arranged dietetic scheme is alike taught by experience and proved by experiment. No single class is capable of sustaining life by itself, although it is certain that health can be maintained for some time on a diet consisting of the nitrogenous, fatty, and saline matters; indeed, the diet of the Esquimaux contains very little, if any, of the carbo-hydrate constituents.

It has further to be noted that the ordinary articles of food represented in common dietaries contain on the average 50 to 60 per cent of water, and in addition from 50 to 80 oz. are daily taken into the system, the amount varying according to the nature of the work, the temperature of the air, and the quantity of stimulants which may be consumed from day to day.

Section II.—Diet and Work

In the subjoined table are given the analyses of different articles of diet in common use, by various analysts, to show the relative proportion of the several constituents. But inasmuch as the phenomena of nutrition depend mainly on the interchange of nitrogen and carbon with oxygen, articles of diet have also been estimated according to the amount

of nitrogen and carbon which they contain as indicated in the second part of the table :—

Articles.	In 100 Parts.					Grains per lb.	
	Water.	Albuminates.	Fats.	Carbohydrates.	Salts.	Nitrogen.	Carbon.
Beef and mutton as ordinarily supplied	75	15	8·4	—	1·6	185	1900
Bacon	15	8·8	73·3	—	2·9	99	4500
Salt beef	49·1	29·6	0·2	—	21·1	325	1115
White fish	78	18·1	2·9	—	1	200	870
Poultry	74	21	3·8	—	1·2	235	910
Flour	15	11	2	70·3	1·7	120	2700
Wheaten bread	40	8	1·5	49·2	1·3	88	1975
Rice	10	5	0·8	83·2	0·5	68	2730
Oatmeal	15	12·6	5·6	63	3	136	2830
Peas (dry)	15	22	2	53	2·4	248	2700
Potatoes	74	2	0·16	21	1	22	770
Green vegetables	91	0·2	0·5	5·8	0·7	14	420
Eggs	73·5	13·5	11·6	—	1	152	1088
Cheese	36·8	33·5	24·3	—	5·4	305	3340
Milk (new)	86·7	4	3·7	5	0·6	45	600
Butter	6	0·3	91	—	2·7	5	6450
Sugar	3	—	—	96·5	0·5	—	2950

The dry albuminates, fats, and carbo-hydrates in any given dietary may be approximately calculated in grains of nitrogen and carbon by first ascertaining the amount of the substances in ounces, and then employing the following factors :—1 oz. of albuminates contains 70 grs. of nitrogen and 212 grs. of carbon; 1 oz. of fat contains 336 grs. of carbon; and 1 oz. of carbo-hydrates contains about 190 grs. of carbon. The total carbon in one ounce of albuminates is 232 grs., but of this 30 grs. are oxidised only as far as urea, so that making allowance for this, the amount of carbon fully oxidised is 212 grs.

As the preceding table contains almost all the articles which are likely to be met with in a common dietary, it becomes no difficult matter to calculate the total amounts of nitrogen and carbon which any such dietary contains, and to compare the result with those of other dietaries which have been calculated in the same way. It is necessary to add that the nutritive equivalents apply to articles

in their uncooked state, and that the meat is boned. When meat is taken in bulk, about 20 per cent should be allowed for bone, and in respect to eggs 10 per cent must be deducted for shell.

From the researches of Lord Playfair, Edward Smith, Parkes, and others, it has been ascertained that the diet of an adult man ranges from 250 to 350 grs. of nitrogen, and from 3500 to 6500 grs. of carbon, daily. According to Edward Smith the average mean of the dietaries of low-fed operatives amounts to 214 grs. of nitrogen, and 4881 grs. of carbon daily, while Playfair found that well-fed operatives consumed an amount of food representing an average daily mean of 400 grs. of nitrogen and 5837 grs. of carbon. On the other hand, the late Dr. Parkes, while experimenting on four healthy men of average height and weight, and employed at ordinary labour, ascertained that perfect health and uniform weight were maintained on a diet containing 293 grs. to 305 grs. of nitrogen. When Medical Officer to the old Convict Prison at Portsmouth, I found that the full labour diet contained 255 grs. nitrogen and 5289 grs. carbon, but extended observation proved that this was inadequate to sustain prisoners employed at hard navvy work for any length of time, and their average loss of weight was so great that they had constantly to be shifted to lighter labour to enable them to recruit. For ordinary artisan work, or lighter out-door work, however, this diet was sufficient.

The separate amounts and relative proportions of the several classes of constituents required in what is called a subsistence diet, a diet for ordinary labour, and a diet for laborious work, required for a healthy male adult of average size and weight (150 lbs.) based on the researches of Moleschott, Playfair, Pettenkofer, Parkes, and others, is approximately represented as follows :—

Water-free Substances given daily.	Subsistence.	Ordinary Labour.	Active Labour.
	ounces avoir.	ounces avoir.	ounces avoir.
Albuminates . .	2·0	4·5	6·5
Fats . . .	0·5	3·5	4·0
Carbo-hydrates .	12·0	14·25	17·0
Salts . . .	0·5	1·0	1·3
Total water-free food	15·0	23·25	28·8

Expressed in grains of nitrogen and carbon the above data yield, for ordinary labour, 315 grs. and 4837 grs., respectively. Generally speaking, the proportion of nitrogen to carbon in all well-arranged dietaries should be 1 to 15.

By referring to the preceding tables it will not only be easy to calculate the nutritive value of any simple dietary, but it is also possible to estimate some of the common articles of food which would be required to sustain health under certain kinds of labour.

Example.—How much oatmeal, milk, and butter of the following percentage composition would furnish the albuminates, fats, and carbo-hydrates, for an average diet?

Would the salts be in the proper proportion or not?

	Water.	Albuminates.	Fats.	Carbo-hydrates.	Salts.
Oatmeal . .	19	12	6	60	3
Milk . .	87·3	4	3	5	0·7
Butter . .	14	0	84	0	2

The albuminates, fats, carbo-hydrates, and salts necessary, may be laid down as follows:—

Albuminates	4·5 ounces.
Fats	3 ,,
Carbo-hydrates	14·25 ,,
Salts	1 ,,

(*Cambridge D.P.H. Exam. Question.*)

Let x = number ounces oatmeal required.
,, y = ,, milk ,,
,, z = ,, butter ,,

then (1) $\frac{12x+4y}{100}=4{\cdot}5$

(2) $\frac{6x+3y+84z}{100}=3$

$$(3)\quad \frac{60x+5y}{100}=14\cdot25$$

or
$$(1)\ 12x+4y=450$$
$$(2)\ 6x+3y+84z=300$$
$$(3)\ 60x+5y=1425$$

From which it will be found that

$y=55$ oz. milk
$x=19\cdot16$ oz. meal
$z=\cdot24$ oz. butter.

Salts.

100 milk	: 55	: :	7 :	·385
100 meal	: 19·16	: :	3 :	·5748
100 butter	: ·24	: :	2 :	·0048
				·9646

The quantity of salts is thus seen to be rather small.

The amount of potential energy derivable from various food-stuffs is based on the assumption that their value as producers of mechanical force will correspond with their value as heat producers, inasmuch as the amount of power which can be obtained from a given weight of matter is proportional to the heat evolved during its complete combustion. According to the English system, what is called the heat unit is the amount of energy required to raise one pound of water one degree Fahrenheit, and this when manifested as mechanical force will raise 772 lbs. one foot high, or 1 lb. 772 ft. high. The potential energy of food stuffs may, therefore, be expressed in terms of heat or work, and tables have been constructed giving the number of heat units and the corresponding amount of energy as foot-tons developed by numerous articles of diet when fully oxidised. Applying this principle to the food-constituents, 1 oz. of dry albuminate is supposed to yield 173 foot-tons, 1 oz. of fat 378 foot-tons, and 1 oz. of carbo-hydrates 135 foot-tons. According to these figures, the average daily diet for ordinary work is capable of yielding about 4000 foot-tons. A large proportion of this potential energy, however, is expended in respiration, circulation, and other internal work. In the first place, the work done by the heart, according to the late Professor Haughton's experiments, is estimated at 260 foot-tons, while the animal heat absorbs from 2000

to 2500 foot-tons in addition, or altogether about 2600 foot-tons may be set down as the amount required for the internal work of the body. Then it has been calculated by Helmholtz that, out of the potential energy, over and above what is required for the internal work of the body, only about one-fifth can be obtained as productive work. For an ordinary day's work, therefore, of 300 foot-tons, about 1500 foot-tons should be supplied by the diet in addition to the amount required for the internal work of the body, or altogether 4100 foot-tons. A strong man can do a day's work varying from 300 to 500 foot-tons or even more.

According to Professor Haughton a man weighing 150 lbs., and walking at the rate of three miles an hour on the flat, does an amount of work equivalent to climbing vertically one-twentieth of the distance travelled. Thus, a man walking a distance of twenty miles on a flat at the rate of three miles an hour does as much work as if he raised his body through a mile in direct altitude, or about 350 foot-tons. The fraction $\frac{1}{20}$ represents the resistance due to traction, and varies according to the rate of speed at which the work is performed—being $\frac{1}{26}$ for two miles an hour, $\frac{1}{16}$ for four miles an hour, and $\frac{1}{14}$ for five miles an hour.

The formula for work done is usually given thus:—

$$\frac{W + W^1 \times D}{2240} \times C = \text{foot-tons},$$

in which W is the weight of the person, W^1 the weight carried,—both expressed in pounds,—D the distance in feet, C the co-efficient of traction ($\frac{1}{20}$), and 2240 the number of pounds in a ton. Thus, to take an illustration:—

Suppose a man weighing 160 lbs. carries a hod of bricks weighing 40 lbs. up a perpendicular ladder 30 feet high, 100 times a day, what amount of work does he do? What would this be equal to in miles walked upon a flat surface at 3 miles an hour? (*Cambridge D.P.H. Exam. Question.*)

First part:—$\frac{(160 + 40) \times 30 \times 100}{2240} = 267{\cdot}8$ foot-tons. Reducing these foot-tons to pounds and remembering that there are 5280 feet in

a mile, the second part is solved as follows according to the above formula :—

$$267{\cdot}8 \times 2240 = \frac{(160 + 40) \times 5280\ D}{20}$$

therefore D = 11·34 miles (at 3 miles an hour).

It now remains to point out the more important principles which ought always to be kept in view in the construction of dietaries; and apart from the influence of work, which has already been considered, they may be briefly summarised as follows :—

1. *Influence of Sex.*—In the case of in-door operatives, the dietaries of women should be about one-tenth less than those of men.

2. *Influence of Age.*—Up to nine years of age a child should be dieted chiefly on milk and farinaceous substances. At ten years of age it will require half as much nutriment as a woman; and at fourteen quite as much as a woman. Young men who have not reached their full growth, but who are doing the same amount of work as adult men, require more food than the latter. In old age the diet should gradually approximate to that suitable for childhood.

3. *Selection of Food.*—This embraces a variety of considerations, such as—

(1) *The relative proportions of proximate constituents.* The mean obtained from numerous experiments by Moleschott, Pettenkofer, Voit, and Ranke is as follows :—albuminates, 100; fat, 82; carbo-hydrates, 272; and salts, 23. Whether the diet be mixed or purely vegetable the same proportions should hold good, and the results of experience prove that they are substantially correct. For example, articles of food which are deficient in one class of constituents are invariably associated with others which contain an excess of them. Thus we have butter, or milk, or cheese, with bread; bacon with veal, liver, and fowl; melted butter or oil with fish, and so on. Such combinations are also of great service in aiding the digestibility of

food. For reasons to be afterwards stated, every dietary should contain fresh vegetables.

(2) *Variety of Food.*—But even when the proper proportions of constituents are provided for in a dietary, it is further necessary that certain articles belonging to the same class be varied from day to day, otherwise the appetite cloys. Beef should alternate with mutton, for example; or variety may be secured by different modes of cooking the same article. Indeed, it is not too much to say that the art of cookery is a matter of national importance, not only because it renders food palatable, but because the more it is studied and practised the greater is the economy which may be effected. It is chiefly in this respect that beverages, condiments, etc. become such valuable dietetic adjuncts.

As already pointed out, in apportioning rations of meat, 20 per cent must be allowed for bone. The loss in weight by cooking varies from 20 to 30 per cent.

(3) *Digestibility.*—This also in great measure depends upon the mode of cooking, though it need hardly be said that some foods are much more digestible than others. As a rule, animal foods are digested sooner than vegetable, and the residues which leave the body are smaller in amount.

4. *Number and Distribution of Meals.*—Experience teaches that three meals daily are best suited to the wants of the body,—the two principal being breakfast and dinner. For those employed at hard manual labour the mid-day dinner is best suited, and for those leading sedentary or easy out-door lives, the late dinner.

5. *Climate.*—Other things being equal, carbonaceous substances ought to contain a preponderance of fatty constituents in cold climates, and of starchy or farinaceous, in warm climates. This also applies to seasonal variations.

Section III.—Preserved Foods

1. *Preserved Meat.*—Meat may be preserved in various ways:—by salting, by pickling, by drying in the sun, by boiling the meat in tins which are hermetically sealed at

the boiling temperature; and by refrigerating in the raw state. This last process is the most successful, and enormous quantities of excellent fresh meat are now imported in refrigerating chambers on board ship from New Zealand, Australia, and America. Before cooking, the meat should be hung up and the moisture which collects on the surface should be wiped off with a clean cloth. Refrigerating chambers would be of immense service as adjuncts to public abattoirs.

Weight for weight, meat preserved in tins is not so nutritious as properly cooked fresh meat, because this process of preservation requires that it should be over-cooked. The great difference in price, however, more than compensates for this disadvantage, and on the score of convenience and economy it deserves to be extensively used. It is best used cold, or warmed and mixed with cooked potatoes and vegetables to form a stew; or it may be minced and warmed.

Among the numerous extracts of meat, Liebig's extract, and Bovril, are perhaps the best known, but there are several other extracts in the market of almost identical composition. According to Dr. Parkes, Liebig's extract is very restorative, removing all sense of fatigue after great exertion. Its nutritive qualities are inferior to those of ordinary beef-tea, but it can be taken by an invalid when beef-tea would be rejected; and it has the further advantage of being readily prepared.

Soups of various kinds, fish, poultry, game, are also sold in large quantities as preserved foods.

3. *Preserved Vegetables.*—When fresh vegetables cannot be procured in sufficient quantity, dried vegetables should be employed to make up the deficiency. In lieu of potatoes in the early part of summer, preserved potatoes may be used; but as they are apt to pall on the appetite, other substitutes, such as a mess of rice and cabbage, pease-pudding, or haricot beans, should be given on alternate days. Preserved peas, tomatoes, and various kinds of fruit may be obtained for the table all the year round.

4. *Preserved Milk.*—Condensed milk as usually prepared

consists of pure milk, or milk sweetened with a little sugar. As one volume of the condensed milk contains the nutritive material of four volumes of fresh milk, it should be diluted with three times its volume of water when used.

Section IV.—Diseases which render the Flesh of Animals unfit for Human Food

Perhaps there is no more difficult task which can devolve upon the sanitary official than to have to decide whether the meat which he is called upon to examine comes from a diseased animal, and if so, to determine the nature of the disease. Even the well-trained and experienced veterinary surgeon, when he is called in to decide, is often at fault. And yet it is most important, in the interests of the public, that this traffic in diseased meat, which, in spite of inspection is still carried on to a scandalous extent, and, especially when infectious disease is prevalent among animals, should be kept in check. It will be well, therefore, to discuss somewhat in detail the leading symptoms and features of the principal diseases which affect animals whose flesh is used for human food; but before doing so it will be of advantage to indicate the main points which characterise healthy living animals, and, briefly summarised, they are these:—The animal's coat should be in good condition, the skin supple and free from scabs, pustules, or sores of any kind. The animal itself should be well-fed and able to move about without signs of stiffness or lameness. Its mouth and nostrils should be free from any discharge, and its breath from offensive odour, while the breathing should be easy and noiseless. Its eyes should be bright, and it should give no signs of shivering or being in pain. If an animal has been driven far to market it will often become footsore, but the resulting lameness will easily be accounted for, and need not therefore be regarded with suspicion.

The most prominent among the diseases which render the flesh of animals unfit for human food are—*cattle-plague, contagious pleuro-pneumonia, anthrax* and *anthra-*

coid diseases, foot-and-mouth disease, varioloid disease, tuberculosis, arthritis, measles, puerperal fever, acute rheumatism, actinomycosis, rot in sheep, pig-typhoid, pig-measles, trichiniasis, fowl-cholera, and acute febrile disorders from whatever cause.

1. *Cattle-plague.*—This disease is highly contagious, but admittedly somewhat difficult to diagnose in its early stages. From the first onset, however, the temperature is variable and rises, the hair becomes dull and erect, the appetite fails, and after a time there is a frequent, dry, short cough. The mucous membrane becomes red and soon covered with patches, and a glairy discharge sets in from the eyes, nose, and mouth, and, in cows and heifers, from the vulva. The ears droop, the secretion of tears becomes copious, there is much shivering and ephemeral muscular contraction, and the animal becomes very restless and sometimes delirious. In a short time purging sets in, and in most cases an eruption appears on the inside of the thighs, udder, and loins.

When the animal is killed the whole mucous tract is found to be reddened and congested, extravasations of blood are generally to be detected in the later stages on the intestines and heart, while the inside of the intestines is covered with a blood-coloured glairy fluid. Except in advanced stages of the disease, the flesh is not much changed in appearance, but it does not set well. When the disease is well developed the flesh is dark, flabby, and has a disagreeable smell, and often crackles, owing to infiltration of air into the tissues.

The propriety of using the flesh of animals killed when suffering from this disease has been discussed for more than a century; but under the Contagious Diseases (Animals) Act its destruction is now absolutely enjoined.

2. *Contagious Pleuro-pneumonia,* though it sometimes attacks sheep and swine, is more especially a cattle disease. The early symptoms are generally slow and insidious, but from the first there is a rise in the temperature, the appetite becomes less keen, the coat becomes rough and

loses its lustre, and eventually a dry, short cough sets in. Later on the breathing becomes laboured, and in coughing the back is arched, and the head and neck extended. At this stage, or even earlier, auscultation and percussion, more particularly over the lower lobes of the lung, will reveal the true nature of the disease. When the animal is slaughtered the pleuræ or lining membranes of the chest and lungs will be found to be rough and thickened, and covered more or less with fibrinous exudation, while the chest cavity is often distended with a large amount of semi-purulent fluid. In the early stages the lungs present a grayish appearance with red or purple patches, and they become less spongy. Later on they are found to be dark and marbled in appearance, resisting and solid on section, and pieces cut off sink readily in water, while their weight is often increased ten or thirty pounds, or more.

The chief characteristic of the flesh is that it usually looks dark and harsh in appearance, and the fat yellow tinged. In order to palm the meat off as sound meat, butchers often strip off the lining membrane from the walls of the chest and smear them with fat, but this artifice may be readily detected on examination. So far as inspection is concerned, it will generally be found that, no matter whether the meat is much diseased or not, it is exposed for sale as sound meat, and as it is thus palmed off on the public under a fictitious character, there ought to be no hesitation in condemning it, especially when the history of the carcase can be fully traced.

When the disease attacks the pig or sheep the same changes will be found in the lungs and on the pleuræ, while the intestines are often inflamed and marked here and there with dark patches.

3. *Anthrax and Anthracoid Diseases.*—From the remotest times these diseases have given rise to widespread and most fatal epidemics, not only among domesticated animals, but among many wild animals. The specific contagium is believed to be a characteristic *bacillus*, the *Bacillus anthracis*, and these *bacilli* crowd the blood of the diseased animal to

such an enormous extent that as many as eight or ten millions have been estimated to exist in a single drop. Fleming divided these diseases into two classes—the general and localised—the former known as splenic apoplexy or anthrax fever, and the latter as carbuncular or anthracoid erysipelas. Other writers, however, distinguish a third form, called *black-quarter* or *black-leg*, characterised by the swelling and dark-coloured appearance of one of the fore or hind quarters. In anthrax fever the disease generally runs a very brief course, sometimes the animals falling as if shot or slain. In other cases, the animals commence to tremble and stagger, the breathing becomes hurried, the pulse rapid, and there is a bloody discharge from the mouth, nostrils, and other passages. In the early stage of the disease there is usually marked thirst, and during the later stage the temperature falls.

Localised anthrax presents itself in two forms—the erysipelatous and carbuncular. In both varieties there is infiltration into the connective tissue under the skin and between the muscles, but in the latter the exudation is more or less circumscribed in the form of tumours under the skin, mucous membranes, and in the connective tissue. In both there is extreme venous congestion, and as a consequence hæmorrhagic extravasations are numerous and well marked. The liver, kidneys, and lungs are congested, often greatly enlarged, and friable. But the most characteristic feature of the disease is the enlargement of the spleen,—the parenchyma of that organ being transformed into a violet or black fluid mass. The flesh is often flabby and dropsical, and rapidly passes into a state of putrefaction; while dropsical effusion may generally be detected between the lobes of fat surrounding the kidneys.

In anthracoid disease of the pig the chief symptoms are thirst, loss of appetite, rigors, hurried respiration, and feverishness. If death does not ensue rapidly, as in the apoplectic form, the snout becomes of a leaden hue, and the ears, belly, and inner surface of the thighs become covered

with red patches which deepen in colour. In the later stages of the disease, as in cattle, the temperature falls, the body becomes cold, and there is a muco-purulent discharge from the eyes. The carcase of a pig thus affected is livid, red, or mottled over most of the surface, the spleen is enlarged, and the flesh is sodden and darker in colour, while blood-coloured patches are generally found on the heart and intestines.

Sheep are more liable to the apoplectic form of the disease than other domesticated animals, and it especially attacks those that are well bred. In the majority of cases there are no apparent premonitory symptoms, the animal often falling down while grazing, and dying in convulsions within a few minutes. In other cases, which are not so rapid in their course, it is observed that the sheep is dull, carries its head low, does not eat, appears uneasy, and, if the herd is moving, drops behind. Its breathing is hurried, the pulse is rapid, the conjunctival membrane congested, and the lower lip becomes marked with patches of a violet hue. When the disease is fully developed, the animal suffers from tremblings, so that it can no longer stand; and there is bloody discharge from the mouth, nostrils, and other passages. Sometimes there is œdema of the neck and flanks; and eventually convulsions set in. External tumours are rarely to be met with in sheep, and then mostly on the head, udder, or inside of thighs. The more common form of the localised disease is a diffused anthracoid erysipelas. In Scotland the splenic apoplexy of sheep is known as *braxy*. The flesh is very dark and often dropsical, and the spleen is increased in weight from two to six ounces.

The uncooked or imperfectly cooked flesh of animals slaughtered for anthrax is extremely dangerous, and numerous widespread and fatal outbreaks of disease in man have been traced to the consumption of food of this description. But if well cooked, it is said that accidents are rare. It need hardly be said, however, that, taking into consideration the great risk, the flesh of all animals

slaughtered when suffering from the disease, or even when suspected to be infected, should be condemned.

4. *Foot-and-Mouth Disease.*—This disease is highly infectious, and attacks cattle, sheep, pigs, and other animals. It is characterised by a rise of temperature and an eruption of small vesicles in the mouth and on the tongue, sometimes extending to the nostrils. It also appears in the cleft and round the top of the hoof; while in cows, ewes, and sows, the teats and udders are commonly affected. The vesicles, though small at first, often become large and confluent, and when they burst they leave bare red spots, which sometimes suppurate. Inside the mouth the vesicles burst soon after they are formed, and in cattle the saliva often becomes tinged with blood. When the limbs are affected the coronet becomes red and swollen, and the animal lame. Sometimes the hoof may be loosened or shed. Occasionally, and more particularly in sheep, the mouth and tongue are affected, or the feet may be very slightly affected without the appearance of vesicles. In severe cases there is much fever, prostration, and thirst; while in sucking animals the disease frequently extends to the pharynx, larynx, and small intestines, and is sometimes of such severity as to induce typhoid symptoms. Except in severe cases, the flesh of animals slaughtered cannot be distinguished from the flesh of healthy animals, and may be passed, but the head, udders, and feet should always be rejected. If, however, the disease has been severe, and there are signs of inflammation or abscesses, or if the flesh is flabby, watery, ill-fed, and sets badly, it ought to be condemned.

Somewhat allied to foot-and-mouth disease, and occasionally mistaken for it, is contagious foot-rot of sheep, which is mainly distinguished from the former by the absence of mouth symptoms. It is in reality a chronic inflammation and ulceration of the soft parts of the feet, and it attacks more especially the purest breeds. It is characterised by lameness and suppuration, which often leads to shedding of the hoof. Except in cases when the inflammation extends

to the carcase, and induces irritative fever and emaciation, the meat may be passed, provided it sets well, but the feet should always be condemned.

5. *Varioloid Disease.*—This disease in cattle, known as cow-pox, is generally so mild and rare that it only merits passing notice. After slight febrile disturbance, which often passes unnoticed, the udder is observed to be swollen near the teats, and in a few days small hard tumours about the size of a pea or bean appear on the teats and udder. These "pocks" gradually increase in size, and attain their maximum development on the eighth or tenth day, when they become purulent, and a crust forms which becomes detached from the eleventh to the fifteenth day. If used for vaccination, the vaccine matter is collected from the eighth to the tenth day before it becomes purulent, and it is at this stage that the disease is most likely to be conveyed to the hands of milkers. Except in very rare instances, the disease runs a mild course.

The disease as it affects sheep is highly contagious and often extremely fatal. After two or three days of more or less severe febrile disturbance, an eruption, at first resembling flea-bites, appears on the inner aspect of the thighs, chest, and belly, extending over the whole body. Towards the fourth or fifth day the eruption becomes vesicular, and afterwards pustular. The eruption often extends to the mouth and nostrils, and the wool readily comes off. Except in the early stages of the disease, the flesh of slaughtered animals has a disagreeable odour, and even in suspected cases is altogether unfit for human food.

The common and fatal disease, sheep-scab, which is caused by a parasite known as the *Psoroptes ovis*, usually disfigures the carcase so much that the flesh is not exposed for sale, and if exposed would be found to be flabby and emaciated. In swine the symptoms of variola are not unlike those of sheep-pox, and the eruption runs a similar course. The disease is highly contagious, and the flesh of slaughtered animals ought always to be condemned.

6. *Tuberculosis*, or consumption, more popularly known

as *pearl disease* or the *grapes*, is a disease which specially affects cattle, and is most common among cows which are kept fastened up in crowded town cow-houses. The disease is slow and insidious in its onset, and may not be suspected until the animal loses in condition and begins to suffer from cough. The pearls or nodules, small at first, but gradually increasing in size, occur on the inside of the walls of the chest, the surface of the lungs, and, as the disease advances, the lungs themselves become affected, and eventually cavities are formed. Although the most common seats of the disease are the lungs, pleuræ, and other serous membranes, the liver, lymphatic, and other glands are often affected, and it has also been asserted that bacilli have been detected in the flesh. On cutting open the nodules they will be found to consist of cheesy-looking matter of the same consistence throughout, or softening towards the centre, and in all tuberculous deposits or discharges Koch's tubercle *bacillus* will be found.

The flesh of animals slaughtered in the early stage of the disease may not present any features differing from those of sound meat, but in the more advanced stage it is pale, flabby, and poorly nourished, and should be unhesitatingly condemned. The signs of pleuritic adhesions on the walls of the chest should be carefully looked for, and the glands should be examined.

According to a recent decision by the Sheriff of Glasgow the flesh of all animals proved to be suffering from tuberculosis should be destroyed as unfit for human food, and though *bacilli* have been rarely discovered in the milk of tuberculous cows, except when the udders are affected, there can be no question that all such milk should be unhesitatingly condemned.

Tuberculosis is also common among pigs, poultry, pigeons, and pheasants, and in respect to these the same rule of condemning as unfit for food should apply. The disease in fowls is commonly known as croup or diphtheria.

7. *Arthritis* in cattle is commonly known as "joint-ill" or "joint-felon." The prominent symptoms are lameness

and inability to rise, feverishness, and swelling of the joints. The serous fluid which is effused into the joints may subsequently become purulent, and abscesses are occasionally found in other parts. Frequently the meat becomes dropsical and should be condemned.

8. *Puerperal or milk-fever* not unfrequently attacks cows after calving, and if the animal is slaughtered when suffering from the disease the meat is certainly unfit for human food. The signs of recent parturition will be apparent, and the flesh will generally be found to be sodden and congested. If the slaughtering is due to some complication in calving or lambing, and the carcase is frankly submitted for inspection, it may be passed if the meat sets well and does not show any signs of congestion. In malignant parturient fever, so common among sheep, the carcase should always be condemned.

9. *Rot in Sheep.*—This disease is the most devastating of all diseases which attack sheep. Its essential cause is the presence in the bile-ducts of the liver of entozoa known as "flukes," small animals shaped like a sole, measuring from about an inch to an inch and a half in length, and when once seen can always be recognised. These flukes attach themselves to the sides of the bile-ducts by means of suckers, and in the later stages of the disease are present in such large numbers that the ducts often become completely blocked up, and even burst, so that the substance of the liver becomes broken down. The prominent symptoms of the disease are dulness, sluggishness, and yellowness of the conjunctivæ; the wool drops off, the animal becomes emaciated, and, as a rule, dropsical. The flesh is found to be thin, watery, and flabby, and the tissues are more or less bile-stained. When the disease becomes pronounced, the flesh is undoubtedly unfit for human food, but the presence of a few flukes in the liver would not warrant the seizure of a carcase, provided the meat looked healthy.

10. *Actinomycosis.*—This disease, though not by any means a new disease, has only been more fully understood of recent years. Like tuberculosis it is communicated to

man, and sometimes so closely resembles that disease that it may be mistaken for it; but its real nature is indicated by the presence of a vegetable micro-organism known as the "ray or fission fungus." The disease is more common among cattle than sheep, and appears in the form of tumours, ulcerations, and abscesses in various parts, but more especially in the head and neck. The new growths characteristic of the disease may, however, attack the tongue, jaw, gullet, nasal cavities, or lungs, and according to their location have been called "wens," "polypi," "cancer of tongue," "lung tubercle," "bone tubercle," or "lumpy jaw." The tumours or growths, when cut through, have a honeycombed appearance, and in the bands of tissue are found the characteristic fungus tufts and yellowish pus. In the United States of America, where the disease is more common than in this country, the flesh of all animals suffering from the disease is condemned as unfit for human food.

11. *Pig-typhoid or Hog-cholera.*—By some writers this disease is classified as identical with anthracoid disease, and, indeed, the symptoms bear a close resemblance to those already described under that heading. The premonitory symptoms are feverishness, restlessness, and rapidity of breathing, after which an eruption begins to appear on the skin, which may be red and patchy, when the disease is called "red soldier," or of a livid tint, when it is sometimes designated "blue soldier." The redness of the skin generally extends through the fat beneath to the muscular tissues, and the intestines often become marked with extravasations. Butchers, in order to disguise the character of the meat, sometimes rub the edges of the reddened fat with salt, but by scraping with a knife, or making a fresh incision, this attempt at deception may readily be detected. The lungs are generally found to be congested, or in parts more or less solidified by pneumonic exudation. When the skin eruption is well marked, it is seldom that the meat is exposed for sale. The eruption sometimes bears a close resemblance to small-pox, pus being secreted and followed

by the formation of crusts. The flesh of all pigs, whether suffering or suspected to be suffering from this disease, should be condemned.

12. *Quinsy*, or "strangles," is a disease which sometimes attacks pigs. It is characterised by sore throat and swelling in the neck, which may extend into the fore-quarters. The premonitory symptoms are laboured breathing, refusal of food, and swelling about the throat, which looks red or livid. The flesh is unfit for human food.

13. *Trichiniasis* or *Trichinosis* is a disease which infests a number of animals, but the chief interest attaching to it is the fact that it is a disease to which pigs are liable, and by eating diseased pork is transmissible to man. The essential cause of the disease is the presence of a parasite known as the *Trichina spiralis* in the muscular tissue of the pig. These parasites are found to exist in three conditions in the animal body—as intestinal, embryonic, or muscular trichinæ. During the period of reproductive or genital activity they inhabit the intestines, and it would appear that in their course of migration they penetrate the intestinal wall, fall into the abdominal cavity, and are discovered earliest in the muscles which enclose the cavity, viz. the diaphragm and abdominal muscles. Other muscles become subsequently infested—the intercostals, muscles of the neck, head, and back, and last of all the muscles of the limbs and tail. In these different regions of the muscular system they continue their development, become at length encysted, and then remain perfectly stationary. Their further development depends upon whether or not the trichinosed flesh is eaten in an uncooked or imperfectly cooked state, when they again pass through similar stages in the newly infested animal, that is to say, breed in the intestines and migrate to the muscular tissues, and in this way they infest man.

In searching for trichinæ in pork, the muscles most liable to be infested should be selected, such as the diaphragm, masticatory muscles near their insertion, or intercostal muscles, and the aid of a powerful pocket-lens or

microscope is necessary. But without the microscope the eye may discern a paleness and œdematous condition of the flesh if the trichinæ are very numerous, while the flesh itself presents a speckled appearance. These small white specks are the spherical or oval cysts in which the parasites are coiled up, and sometimes they feel gritty owing to the presence of carbonate of lime. In order to examine them microscopically, a very thin shaving of the flesh in the direction of the muscular fibrillæ should be placed on a glass slip and soaked in a solution of liquor potassa (one to eight or ten of water), but for only a few minutes. The section should then be teased out with needles, protected by a covering glass, and placed in the field of a microscope with a magnifying power of 50 to 200 diameters. If the capsule is thick and opaque, owing to the presence of carbonate of lime, a drop of weak solution of hydrochloric acid will render it transparent; and should a little fat obstruct the view, a drop of ether or benzin will remove it. The fully-developed trichinæ, in their genital stage, must be looked for in the small intestines, more particularly in the layer of mucus covering the lining membrane of the duodenum. In the migratory stage of the undeveloped trichinæ, and before they become encysted, a high power is necessary for their detection. Swine infested with the disease may not present any noticeable symptoms during life. The flesh should invariably be condemned.

14. *Measles in the Pig.*—This disease, like the preceding, is due to a parasite or entozoon, in the form of a bladder-worm, known as the *Cysticercus cellulosus.* It is much larger than the *Trichina spiralis,* and is developed from the ova of the human tape-worm (*Tænia solium*), which are expelled from the intestine along with the fæces. These ova are swallowed by the pig when it devours infested fæces, and the embryos which they contain are developed into hydatids. Each embryo is provided with six hooklets, and soon after being introduced into the interior of its host, it commences to penetrate the tissues in its immediate neighbourhood, until it has reached a

favourable position, when it assumes the hydatid or bladder form. This it maintains permanently, unless it is transferred by the meat, which it infests, to the intestinal canal of man, when it develops into the fully matured tape-worm. The cysticercus is contained in an egg-shaped bladder, varying in size from an eighth to three-eighths of an inch in length, and surrounded by fluid. Unlike the cysts of the *Trichina spiralis*, which are embedded in the substance of the muscular fibrillæ, these bladders are found between the muscular fibres, and often on the surface of the muscles. To examine one of these bladders, it should be put on a glass-slip and incised, when, with the aid of a good pocket-lens, the worm will be found curled up in the cavity. It is about one-third of an inch in its longest diameter, or varying from the size of a pea to that of a cherry, and in its retracted state it is somewhat oval or elliptical. In order to examine the head it is necessary to extract it from its cavity or *receptaculum* with fine needles, when it is found to be square-shaped if viewed from above, and conical when viewed in profile. It is furnished with four muscular suckers, and the small depression at the apex of the head is surrounded with hooklets, varying from twenty-four to twenty-eight in number, which, when once seen, cannot be mistaken. The muscles of the tongue, neck, and shoulders are most liable to become infested, and next in order the intercostal muscles, and those of the lumbar region, loins, and thighs; while sometimes hydatids may be detected in large numbers in the muscular substance of the heart, and in the liver, lungs, and brain.

The disease more particularly affects young pigs, and those verging on maturity. The symptoms are very variable, and in mild cases the disease may not be suspected. If suspected, it is usual to examine the under surface of the tongue, when frequently the little bladders may be felt or seen. In the more advanced stage of the disease they may be detected under the tail, round the ears, or in the conjunctival membrane of the eye. When the disease

becomes general and severe there is loss of appetite, the animal becomes stiff and awkward in its movements, and swellings are more particularly observed around the withers. Pork infested with these parasites is called *measly*, owing to the characteristic appearance of the flesh on section. When the flesh is dried or salted, the cysts shrink, and in order to detect them a small slice should be steeped in water. The flesh of measled pigs should not be used as food, even though the hydatids may apparently be few in number.

Measles in the ox, like pig-measles, is also parasitic, the entozoon being the larval cestode of the *Tænia mediocanellata*, which is a human tape-worm infesting the small intestine. The symptoms of the disease, the development of the entozoon, and the appearance of the infested flesh and cysts, so closely resemble those already described respecting the *Cysticercus cellulosus* in the pig, that no further description is necessary. The meat should be condemned.

There is another parasite having for its habitat the lungs of sheep or oxen which may be mentioned here. It is known as the *filaria*, a thin worm from half an inch to three inches in length. It is not a common disease, and unless it induces severe inflammation of the lungs, fever, and emaciation, the meat may be passed.

Immature veal or lamb should be condemned as unfit for food if the animals have been born prematurely, or have died during birth, when the flesh is known as "slink meat." It should also be remembered that the flesh of animals may become unwholesome owing to the animals having been accidentally or maliciously poisoned, and in these cases the meat may look perfectly healthy provided the animal has been slaughtered. In suspicious cases of this description, the stomach and intestines should be carefully examined for traces of inflammation, and the first stomach, for pieces of meadow-saffron, bryony, or yew-leaves, etc. The flesh of animals slaughtered on account of accident may be passed, provided that the accident has

not led to severe febrile disturbance, and the meat sets well; but if the animal has died from accident, the meat should be condemned, because the carcase has not been bled. The flesh is dark in colour, full of blood, sets badly, and rapidly decomposes.

It may further be laid down as a rule, that if an animal has been slaughtered while suffering from marked febrile symptoms, from whatever cause, or from inflammation of a severe type, pyæmia, erysipelas, or uræmia, the carcase should be condemned as unfit for human food.

Section V.—Examination of Food

1. *Butcher Meat.*—A healthy carcase should be well-bled, no part of it being dark or speckled, bruised or bile-stained. The meat should set well, as soon as the carcase cools, and should not present an emaciated appearance. It should not be flabby or pit on pressure, nor should it crackle, because this would indicate the presence of air.

When a carcase is inspected, the offal should be inspected too, and it should always arouse suspicion if the butcher says he has destroyed or thrown away the offal and cannot produce it. In oxen and sheep the offal consists of the head, hide, feet, and all the internal organs with the exception of the kidneys; but in pigs the head, feet, and skin form part of the carcase. In examining the offal it should be noted that the skin is free from sores or pustules, that there are no signs of bruising, and that the hoofs are healthy-looking and firmly attached to the feet. The mouth and tongue should be free from patches or ulcers. The internal lining of the stomach should present no signs of inflammation, and should have no smell of physic, while the intestines should have a smooth uninflamed lining, and be free from ulcers or patches. The liver should not be friable, be of a rich brown colour, and free from abscesses or flukes. The spleen should be a gray colour outside, thin, long, and sharp (not rounded), at the edges, and on section should be dark inside. The lungs should be of a pink,

bright colour, and spongy, and portions cut off should float in water. They should also be free from cavities, pus, or worms, and their surfaces should present no signs of inflammatory patches, or recent pleuritic adhesions.

In order to acquire a practical knowledge of the healthy appearance of sound butcher-meat, whether in carcase or cut up for sale, the sanitary official should make repeated inspections of the contents of a butcher's shop whose trade is above suspicion, and he should also visit the slaughter-house and make careful examination of the various parts of the offal, and pay particular attention to the usual way in which carcases are dressed. His knowledge of unsound meat and diseased offal would be most readily gained by accompanying a meat-inspector on his rounds in one of our large towns.

The characters of good meat may be enumerated as follows:—

(1) On section it should present a marbled appearance from intermixture of streaks of fat with muscle. This shows that the animal has been well fed.

(2) The colour of the muscle should neither be too pale nor too dark. If pale and moist, it indicates that the animal was young or diseased; and if dark or livid, it shows that in all probability the animal was not slaughtered, but died with the blood in it. The muscles in pork, veal, and lamb are pale.

(3) Both muscle and fat should be firm to the touch, not wet or sodden. The latter should be free from hæmorrhagic points, and the suet fat should be hard and white.

(4) Any juice exuding from the meat should be small in quantity, be of a reddish tint, and give a distinctly acid reaction to litmus-paper. Good meat should dry on the surface after standing a day or two, and so long as it yields an acid reaction there is no decided putridity. The juice of bad meat is alkaline or neutral.

(5) The muscular fasciculi should not be large and coarse, nor should there be any mucilaginous or purulent-

looking fluid to be detected in the intermuscular cellular tissue.

(6) The odour should be slight, and not by any means disagreeable. An unpleasant odour indicates commencing putrefactive change, or that the meat is diseased. By chopping a portion of the meat into small pieces, and afterwards drenching it with warm water, any unpleasantness of odour will be more readily detected. Another good plan is to thrust a long clean knife or skewer into the flesh, and smell it after withdrawal.

(7) When meat is salted, the brine should not become sour or offensive.

When meat becomes bad through partial decomposition, owing to its having been kept too long, its chief characteristic is an offensive or putrid smell. The external surface is pale or livid, and, at a later stage, greenish. The meat is soft, tears easily, and loses its elasticity, and the juice is alkaline or neutral. The flesh of animals which have not been slaughtered, or only slaughtered when in a dying state, is dark in colour and often purple, full of blood, sets badly, and readily decomposes. Diseased meat is usually sodden and flabby, often emaciated, with the fat discoloured or gelatinous-looking, and the smell unpleasant and sickly. The ribs should always be examined for pleuritic adhesions, and in cases of suspected dropping after calving, the udders and peritoneal lining should be carefully scrutinised, while in all cases the flanks should be looked to, because it is generally in these parts that putrefactive change first sets in. When the offal can be obtained for inspection the various organs should be minutely examined, but it is seldom that the butcher who wishes to sell diseased meat leaves any of them exposed to the risk of detection, and this, as already said, should always arouse suspicion. If parasitic disease is suspected, the muscular fibre should be examined under the microscope. Cysticerci, though generally visible to the naked eye, can be accurately detected under a low power or by means of a good pocket-lens, and the hooklets should be always seen.

In searching for trichinæ, it should be remembered, as previously stated, that the parts most likely to be infested are the diaphragm, the intercostal muscles, and the muscles of the flank.

Any departure from the natural colour of the flesh of a slaughtered animal should arouse suspicion. A magenta hue, a dark reddish brown or black hue, or a mahogany hue, are all of them indicative of diseased conditions, while a greenish hue is a sure sign of decomposition or gangrene. Iridescence, or "Peacock feather glint," according to Walley, is seen on section under a variety of circumstances, as in blood diseases, prolonged febrile disorders, and difficult parturition. Attention, too, has been directed to a phosphorescent appearance presented by meat in the dark such as is often presented by fish. Though this appearance is no doubt very rare, it would warrant, according to Walley, the condemnation of the meat as indicative of grave histological changes.

When meat is seized, very often the defence is set up that it is intended for dogs' meat; but if it is found in the butcher's shop, or dressed in the usual way, there is generally very little difficulty in obtaining a conviction. In cases of this description which are brought before the magistrates, and likely to be strongly contested, it is always advisable, if possible, to get extraneous evidence concerning the previous history of the animal, and the price at which it was sold, and in country districts this can often be ascertained.

There is no doubt that large quantities of diseased meat are used up in the making of sausages, and instances of serious illness arising from food of this description are not at all uncommon, especially when the sausages are not well cooked. Bad-smelling sausages, or sausages which have a nauseous or putrid taste, an acid reaction, or a soft consistence in the interior, are highly dangerous and should always be condemned. Tinned meats too, and so-called potted meats, are liable to putrefactive change, and should therefore be carefully examined,

particularly as regards smell and taste, before being used.

Before leaving this part of the subject, it may be stated that it is the practice in the City of London to condemn the flesh of all animals infected with parasitic disease, such as measles, flukes, etc.; of animals that may have been suffering from acute, febrile, or wasting diseases; and of those which have died from natural causes or by accident; as well as all meat tainted by physic, or in a high state of putrefaction. It is also the practice to condemn the flesh of any animal which has been killed immediately before, during, or immediately after parturition, on the presumable grounds that an animal would not be slaughtered under such circumstances unless death appeared to be impending. In cases of complicated parturition, however, or of accident, or of purely local mischief, such as intestinal obstruction, the carcase may be passed as fit for food, provided the animal was slaughtered before inflammatory or other constitutional symptoms set in.

2. *Horse-Flesh.*—Under the Horse-Flesh Regulation Act of 1889, horse-flesh shall not be sold as human food unless in a shop, stall, etc., conspicuously labelled. The flesh of the horse is darker than that of the ox, and the muscular fibre coarser. The fat is also of a yellowish colour, and softer. If the meat has not been boned there will be no difficulty in distinguishing it from ordinary butcher meat, because the bones and joints are much larger, and the ribs, which are more numerous than those of the ox, are more arched.

3. *Poultry.*—Good poultry should be fairly well fed, firm to the touch, and present a pink or yellowish colour, while the smell should be fresh, and not unpleasant. Stale poultry becomes bluish in colour, often green over the crop and abdomen, has a disagreeable odour, and the skin breaks readily.

It has been discovered during recent years that *tuberculosis* is a frequent disease not only of the poultry-yard, but of the pigeon-loft and pheasantry. In poultry

the affection has been variously described as *croup* or *roup*, *diphtheria* and *diphtheritic aphtha*, but the discovery of the *bacilli* of tuberculosis has served to dissipate these theories. The disease commences in most instances in the mucous membrane of the mouth, the nostrils, or the eye, then extends to the mouth and throat, and later on to the bowels, mesentery, and liver. In the lungs the disease presents a croupous appearance, but in the walls of the crop and of the intestines, and in the liver, mesentery, and spleen, the lesions are nodular.

Fowl-cholera is another disease which may affect geese, ducks, turkeys, and pigeons, as well as domestic fowls. It is seldom, however, that any birds so affected are exposed for sale. The symptoms of fowl-cholera when the disease does not become rapidly fatal are briefly these:— The feathers present a bristling appearance, the comb becomes limp and livid, the wings droop, the bird loses appetite and drinks much, and becomes swaying or dragging in its gait. Eventually diarrhœa sets in, muco-purulent at first, and later on streaked with blood. If the bird dies or is killed and prepared for the market, the flesh is found to be somewhat redder than usual, the substance of the liver more friable, and the interior of the intestines marked with extravasations. Decomposition sets in rapidly.

4. *Game.*—According to modern ideas game must be in a state of decomposition, or what is called more or less "high," before it is considered to be fit for the table. It is therefore very difficult to decide when such a stage of decomposition has been reached as would warrant its seizure. But when the flesh becomes putrid, and the odour offensive, there is no doubt that it is unwholesome and should be condemned.

As already pointed out, tuberculosis is a disease to which game, and, it may be added, rabbits are liable, and should any of the characteristic lesions be detected, there should be no hesitation in condemning.

5. *Fish.*—Fresh fish should be firm, and without any disagreeable odour. If the whole fish is held out hori-

zontally there should be very little drooping of the tail. The fish usually hawked about the streets is generally more or less limp and soft, and if it is found to be offensive as well, there is no doubt that decomposition has set in, and that it is unwholesome. But fish which is apparently healthy often gives rise to serious symptoms, such as vomiting, diarrhœa, and prostration. Herrings, pilchards, and other kinds of fish may occasionally induce symptoms of poisoning, and it is not at all an uncommon occurrence to find a prickly rash following the eating of healthy shell-fish.

6. *Fruit and Vegetables* may become unwholesome from decay or disease, and the principal indications are softening, discoloration, or mouldiness. Unripe food, such as windfall apples, are certainly unwholesome, unless well cooked. Good potatoes should be of fair size, give no indications of disease on section, be firm to the touch, and when cooked should not be close or watery. Potatoes which have been exposed to severe frost become soft and watery, and are rendered unfit for food.

Tinned fruits and vegetables, like tinned meats, are generally more or less contaminated with tin; but as the metal is not poisonous except in large doses, the small amount which is generally found to be present is not injurious. Green peas, French beans, and other vegetables, such as pickles, are frequently adulterated with copper to retain the fresh green colour. This adulteration is no doubt injurious, and may readily be detected by leaving the clean blade of a knife in the liquor for a short time, when the copper will become deposited on the blade.

7. *Corn.*—This includes wheat, barley, oats, rye, rice, and maize. *Smut*, *bunt*, and *ergot* are the most common diseases affecting corn in this country, ergot especially affecting rye; bunt, wheat; and smut, barley and oats. They are all of them vegetable parasites, distinguishable under the microscope. Stored corn may become infested with an insect known as the weevil, or by *acari*, and if

stored when damp, may become unwholesome owing to fermentive changes.

8. *Flour.*—What is called good household flour or "seconds" should contain very little bran, be quite white, or only slightly tinged with yellow, and should give no acidity or musty flavour to the taste. It should not be lumpy or gritty to the touch, nor should it yield any odour of mouldiness to the sense of smell. When made into a paste with a little water, the dough should be coherent and stringy, and even in the dry state it should cohere when compressed.

The amount of gluten can be ascertained by washing carefully a known quantity of flour, made first into a rather stiff dough, until the water comes off quite clear. The gluten, when baked or dried, should be clean-looking and should weigh at least 8 per cent of the quantity of flour taken for examination. A good flour will yield 10 to 12 per cent. Bad flour gives a dirty-looking gluten, which is deficient in cohesion, and cannot be drawn out into long threads.

Flour is sometimes adulterated with barley-meal maize, rice, potato-starch, etc. Samples of doubtful quality should therefore be examined microscopically. *Fungi, vibriones,* and the *Acarus farinæ* are detected in flour which is undergoing putrefactive change.

Adulterations with mineral substances, such as chalk, gypsum, or carbonate of magnesia, are best detected by burning a weighed quantity of flour down to the ash, which should not exceed 2 per cent.

What is called whole meal should always be well ground, and should give no acid or mouldy taste.

Oatmeal is generally roughly ground, and contains a fair amount of envelope freed from the husk. If husks are present the probability is that the meal has been adulterated with barley. The starch should not be discoloured, and the meal itself should be agreeable to the palate. If the meal looks suspicious, it should be examined microscopically.

9. *Bread.*—The crust should be well baked, not burnt. The crumb should not be flaky or sodden, but regularly permeated with small cavities. The taste and smell should both be agreeable and free from acidity. Unless there is a considerable quantity of bran in the flour, as in whole-meal bread, the colour should be white, not dark or dirty-looking. Bread is aerated with leaven or yeast, by kneading the flour with water charged with carbonic acid, or by mixing it with baking powders. Unleavened bread, and many kinds of cakes and biscuits, are not aerated.

Bread may become heavy and sodden owing to bad flour, bad yeast, or a gummy mixture of ground-rice. It may become sour owing to the quality of the flour, or to excess of fermentation, or it may become mouldy owing to its having been kept too long, or stored in a damp place. Biscuits, and especially ship biscuits, are often attacked by weevils.

Good flour, well baked, yields about 136 lbs. of bread per 100 lbs. of flour, and adulteration is chiefly directed to increase this ratio by making the gluten hard, and the bread more retentive of water. Ordinarily a 4-lb. loaf loses about $1\frac{1}{2}$ oz. in twenty-four hours, and about 5 oz. in forty-eight hours. Wheaten bread is sometimes adulterated with barley-meal, oatmeal, or boiled rice, and in order to improve its appearance when it is made from inferior, damaged, or adulterated flour, a small quantity of alum is added, generally less than 50 grs. to the 4-lb. loaf. The readiest test for alum in bread is the test known as the log-wood test. A tincture of log-wood is made by digesting 5 grammes of log-wood chips in 100 cubic centimetres of strong alcohol, and a solution of ammonia is made by dissolving 15 grammes of carbonate of ammonia in 100 cubic centimetres of distilled water. A teaspoonful of the tincture of log-wood, and the same quantity of the ammonia solution, are mixed with a wine-glassful of water, and in this mixture a small crumb of the bread to be tested is allowed to remain for about five minutes. The bread is then removed, and dried at a gentle heat, when, if much

alum is present, the bread dries of a dark blue colour; if only a little, the colour is lavender; and if no alum be present, the bread dries of a dirty brown colour.

10. *Milk.*—Pure cows' milk, when placed in a tall narrow glass vessel, should be perfectly opaque, of a full white colour, free from deposit, and should yield from 8 to 12 per cent of cream by volume, the average being 10 per cent. When boiled it should not change in appearance, and when allowed to stand for some time there should be no deposit. As it is frequently adulterated with water, the specific gravity is an approximate test of the quality, and hence the use of the lactometer. The specific gravity varies from 1027 to 1036: if it falls below 1027 it shows that the milk is either very poor, or that a certain amount of water has been added. The following table by Letheby indicates approximately the amount of water adulteration according to the specific gravity and percentage of cream:—

	Specific Gravity.	Percentage volume of cream.	Specific Gravity when skimmed.
Genuine milk	1030	12·0	1032
Do. with 10 per cent water	1027	10·5	1029
Do. ,, 20 ,, ,,	1024	8·5	1026
Do. ,, 30 ,, ,,	1021	6·0	1023
Do. ,, 40 ,, ,,	1018	5·0	1019
Do. ,, 50 ,, ,,	1015	4·5	1016

According to Wynter Blyth, the following table gives the average percentage composition by weight of human milk and cows' milk:—

	Human Milk.	Cows' Milk.
Fat	2·90	3·50
Casein	2·40	3·98
Albumens, etc. . . .	0·67	0·94
Milk Sugar	5·87	4·00
Salts	0·16	0·70
Total Solids	12·0	13·12
Water	88·0	86·88

After milk has been allowed to stand from four to eight hours, the cream rises, and the remainder of the milk

becomes less opaque. The quantity of cream which separates varies from 6 to 12 per cent, or even more—a small percentage of cream being always retained by the milk, even although it is allowed to stand for twenty-four hours. A much larger average percentage of cream can be obtained by the centrifugal apparatus, known as the "Separator," which is now largely used in dairies. The milk which is milked last at a single milking is called the "strippings," and is much richer in cream than the milk first milked, called the "fore-milk." Milk, too, varies very much in quality and quantity according to the breed of the cow, her age, health, number of pregnancies, the period which has elapsed since calving, and the nature of the food upon which she is fed. About twelve quarts is the daily average yield, but immediately after calving the yield may be double this quantity. The first milk obtained after calving is called *colostrum*, popularly known as "beestings." It is of a high specific gravity—about 1050, of a rich yellow colour, clots very readily, and has a taste somewhat like beaten eggs. It is unwholesome and ought not to be used until it presents a healthy appearance and taste.

If cows' milk is used for the feeding of infants under nine months of age, it should be given diluted with water and the addition of milk sugar.

To prevent dense clotting in the stomach pearl barley water, well-boiled and strained, may be used instead of water to dilute. All milk used for infant feeding should be boiled or sterilised. Asses' milk and goats' milk approximate much more closely to human milk than cows' milk in composition, inasmuch as they contain less casein and yield a more flocculent digestible curd.

In addition to the sterilising process, milk is sometimes preserved in a dessicated form—the water being driven off by evaporation; or it can be obtained in a highly concentrated form as "condensed milk." What is called "koumiss" is a fermented drink prepared from mare's milk and has long been used in Russia and Tartary, but "koumiss" is now largely made in this country from cow's milk and con-

stitutes a valuable food for invalids because it is easily digested and readily absorbed.

In most cases of falsification or adulteration, milk is watered or creamed, or both watered and creamed, and what is sold as new milk is often largely mixed with skimmed milk. Watering is detected by a lowering of the specific gravity, and a diminished percentage of cream; but when creaming alone is resorted to, the specific gravity is raised and the percentage of cream diminished. When both are resorted to, the specific gravity may be normal, but the percentage of cream is of course always lessened. When milk has been falsified in this way, other substances, such as treacle, turmeric, carbonate of soda, etc., have sometimes been added to improve the flavour and appearance; but such sophistications are now very rare. Generally speaking, the use of the lactometer to determine the percentage of cream, and test the specific gravity, will enable one to give a reliable opinion as to whether the milk has been tampered with or not. Suspicious samples should be sent to the public analyst for analysis.

In order to prevent fermentative changes when milk is conveyed long distances from country farms, it has recently become a somewhat common practice to add a little salicylic acid, boracic acid, or boroglyceride to the milk, and these adulterants constitute another possible danger.

It may be laid down as a safe rule that all milk from diseased animals should be condemned. The normal constituents of milk as seen under the microscope consist of round oil globules, enveloped in a cyst, and scattered epithelial cells; but in milk obtained from diseased animals, blood, pus cells, and aggregated granules may often be detected, and sometimes casts of the lacteal tubes, while bacteria and small oval and round cells are not at all uncommon.

Disease in the cow often arrests, and almost always diminishes, the flow of milk, except it be in cases of tuberculosis, when it becomes watery and poor in quality.

Indeed, a marked diminution in the flow of milk from any cow should at once arouse the suspicion of the dairymaid, and the milk for the time being should be excluded from the common stock.

But apart from cow conditions affecting milk which will be discussed more fully in the following section, milk often becomes unwholesome by keeping, especially in warm weather. The sugar is converted into lactic acid by microbic fermentation and becomes markedly sour; the milk curdles, the whey separating from the curds; the lactic acid is converted into butyric acid by further microbic action, and finally putrefactive changes are set up by saprophytic organisms.

11. *Butter.*—Butter should give no unpleasant or rancid taste. Adulteration with water or animal fats is best detected by melting the butter in a test-tube; the water, salt, or other substances remaining at the bottom. After separation of the casein by melting, good butter is entirely soluble in ether at 65° Fahr., while the fat of beef or mutton dissolves with great difficulty, and leaves a deposit. Adulteration with potato or other starch can be at once detected by iodine. Good butter, when melted in a tall glass, should yield over 80 per cent of fat, the water and curds collecting at the bottom, leaving the pure fat as a clear-looking oil above. Adulteration with lard or other animal fats raises the melting point, while vegetable fats lower it. The butter made in dairies in which scrupulous cleanliness of premises and utensils is not maintained, or from milk obtained from cows tied up in foul cowsheds, is apt to become rancid, and is often badly flavoured.

12. *Margarine,* which is sometimes sold as butter in contravention of the Margarine Act, is composed chiefly of fats of animal origin, and is treated with milk or genuine butter to make it resemble butter as closely as possible.

13. *Cheese.*—The quality of cheese is determined by the taste and consistence. Inferior cheeses are often soft and leathery, owing to the amount of water which they contain.

Starch, which is sometimes added to increase the weight, may be detected by iodine. Cheese consists of casein coagulated by rennet, and it also contains a variable proportion of fat and salts. When it undergoes what is called the "ripening" process, oxygen is absorbed, ammonia and carbonic acid are given off, and the casein undergoes fatty metamorphosis. Cheese fermentation sometimes develops an irritant poison, known as *tyrotoxicon*, which causes dryness of the mouth, nausea, vomiting, diarrhœa, and extreme prostration. The same poisonous substance is sometimes developed by butter and cream.

14. *Eggs.*—An average-sized egg weighs about 2 oz. avoir. Fresh eggs, when looked through, are more transparent at the centre; stale ones, at the top. In a solution of 1 of salt to 10 of water, good eggs sink, while the stale ones float.

15. *Tea.*—The quality of the various kinds of tea imported into this country has greatly improved of late years. Any attempts at adulteration are best detected by shaking the leaves in cold water, straining through muslin, and afterwards examining the leaves and deposit. Inferior mixtures, such as Maloe mixture, Moning congou, Pekoe siftings, etc., consist of exhausted tea-leaves, leaves of other plants, iron-filings, etc., with only a little good tea.

Good tea should yield a pleasant aroma, alike in the dry state and when infused in boiling water, and the flavour of the infusion should be agreeable. The test for tea of the first quality is to put a small quantity in a cup, pour water at the boiling point on it, taste it for its flavour, then allow it to stand until it cools, when it should throw up what is called a cream. The leaves, when spread out, should be small, serrated, elongated, and liver-coloured.

16. *Coffee.*—The principal adulteration of coffee is chicory. The adulteration may be detected either by microscopic examination or by sprinkling a portion of the suspected sample on the surface of water, when the coffee will float and the chicory sink. The presence of chicory is also indicated, if, on opening a packet of coffee, the

contents are found to be caked, or show any signs of caking.

Amongst other articles of food or drink which are liable to adulteration may be mentioned cocoa, mustard, pepper, confections, beer, wine, and spirits; but without entering further into this part of the subject, it will be sufficient to point out that any article of food or drink, or any drug which is supposed to be adulterated, should be submitted to a public analyst, on whose report proceedings may be taken under the provisions of the "Sale of Food and Drugs Acts, 1875 and 1879."

Section VI.—The Effects of Insufficient or Unwholesome Food on Health

1. The minor effects of insufficient food are generally so intimately associated with those of other causes of disease, that it is impossible to estimate, with any approach to accuracy, their separate influence on public health.

Only those who have threaded the dingy streets and dirty courts of our large towns can form any adequate conception of the widespread suffering and disease which follow in the wake of actual want. Clothing and fuel even scantier than the food, overcrowding with all its attendant evils, sanitary arrangements of the filthiest description, uncleanliness of person and home, all contribute to the heavy load of misery which the destitute have to bear. Indeed, as regards the civil population, the history of relapsing fever is almost exclusively a history of the ravages of disease arising from destitution, and the famines of the present century, especially those of 1817 and 1847, need only be referred to as evidence on this point. There is no doubt, too, that the large mortality among infants and young children is in great measure due to insufficient food, and at all ages there are crowds who from sheer want fall ready victims to some form of adynamic disease.

2. *Unwholesome Food.*—Although much of the apparent immunity from disease enjoyed by the large numbers who

unwittingly indulge in unwholesome food at times is to be attributed to the antiseptic power of good cooking, there are also many instances on record in which food of the most putrid description is devoured without producing any ill effects. Thus, there are whole tribes of savages who eat with impunity rancid oil, putrid blubber, and stinking offal; and in this country game is not considered to be in a fit state for the epicure's table until it is undergoing rapid putrefactive change. Admitting all this, however, there is abundant evidence to prove that serious consequences resulting from the use of unsound meat are of frequent occurrence, and in all probability a large proportion of cases of obscure disease owe their origin to the same cause. Moreover, it is but only logical to conclude, from general principles, that, as all diseases must affect the composition of animal flesh, and as active putrefactive change must at all events deteriorate its nutritive value, it is of the utmost importance to health that these substances should be obtained in as sound a condition as possible.

The following is a brief abstract of the more important facts connected with this part of the subject:—

(1) *Diseased Meat.*—In the numerous cases of illness which have been attributed to the use of diseased meat, the symptoms are very similar to those occasioned by the use of putrid meat, and are chiefly confined to the gastro-intestinal tract. The exceptional symptoms apply chiefly to the transmission of specific or parasitic disease. Thus, numerous instances have been recorded in which persons have been seized with malignant pustule after eating the meat of animals suffering from anthrax, and there is an increasing amount of evidence which goes to prove that tuberculosis may be transmitted to man through eating the flesh of animals suffering from this disease. As regards the development of parasitic disease, reference has already been made in the previous section to the fact that the *Cysticercus cellulosus* in measly pork produces the *Tænia solium*, and that of the ox or cow the *Tænia mediocanellata*. The *trichina* disease, again, which was so pre-

valent in Germany and elsewhere a few years ago, is due to the *Trichina spiralis* in the pig; while the *ecchinococcus* disease, so common in Iceland, owes its origin to the flesh of sheep and cattle which have become invested by the *tænia* of the dog. It appears that all these parasites are destroyed if the meat is thoroughly cooked before eating.

(2) *Putrid Meat.*—When putrefactive change sets in whether in butcher-meat, fish, fowl, or any other kinds of animal food, certain alkaline substances known as *ptomaines* are produced, which are highly poisonous. These ferments are manufactured by the microbes of decomposition, and may continue active after the microbes themselves have been destroyed. In Dr. Lauder Brunton's Croonian Lectures, delivered in 1889, he refers at length to some very interesting experiments conducted by himself and Dr. Allan Macfayden, which are of special interest to the sanitarian in the light thrown upon the relation of the ferments, formed by microbes, to poisoning by meat. His conclusions are as follows: "The practical application of these results in regard to the prevention of disease is that they seem to show that meat which has become tainted by the presence of putrefactive microbes may possibly be cooked sufficiently to destroy the microbes themselves, while the ferments they have formed continue to decompose the meat, and gave rise to poisonous substances. We can thus see how a cold beefsteak pie, or other meat, may become poisonous and produce serious symptoms, although the same food may have been eaten with impunity immediately after being cooled, for during the process of slowly cooling, poisons may have been formed in the meat." He also points out that there are strong reasons for believing that the poisoning properties of these ferments are greatly intensified when they are produced by the combined action of ordinary putrefactive bacilli and the microbes present in the tissues of diseased animals.

It should also be borne in mind that in some cases poisonous properties are imparted to tinned meats by the action of their juices on the metal, and further that the

envelopes of sausages, saveloys, etc., may in themselves be injurious. In the case of black puddings, again, there is the superadded danger of the possibility that the animal from which the blood has been obtained may have suffered from anthrax or some form of blood-poisoning.

Among the best-known outbreaks of food-poisoning may be mentioned the Welbeck outbreak, which was investigated by the late Dr. Ballard in June 1880. In this outbreak 72 persons were attacked with intense diarrhœa accompanied by febrile symptoms after a public luncheon, and 4 of the cases died. The outbreak was traced to hams undergoing putrefactive change which were found to be infested with micro-organisms, and these on cultivation proved lethal to small animals. Another outbreak of much the same character, in which 15 persons were attacked and 1 died, occurred in Nottingham in February 1881, and was found to be due to eating baked pork (see *Report of Medical Officer of Local Government Board*, 1881). A third outbreak, depending upon pork-pie poisoning, occurred at Retford in 1887. In this outbreak 70 persons were attacked, and one case proved fatal. The implicated pies were made from the flesh of a pig which was believed to be healthy when slaughtered, because no other cases of illness could be traced to the eating of the pork in its fresh state. Further, the pies had been cooked in a baker's oven, at a temperature of about 200° Fahr. or above, and assuming that the meat had been properly sterilised by cooking, the inquiry showed that it must have developed its noxious qualities in about forty-eight hours. But, as in the previous two outbreaks, Klein found minute bacilli, which on cultivation proved fatal to mice (see *Supplement to the Sixteenth Annual Report of Local Government Board*).

Numerous similar outbreaks of food-poisoning have been recorded during the last ten years, and the fact that in all of them the onset of the attacks are so very sudden after partaking of the implicated food, points to the conclusion that the symptoms are produced not by the putrefactive bacteria or bacilli found in the food, but rather by the

ptomaines or other muscarine-like poisons developed by their action.

The symptoms induced by food-poisoning are chiefly confined to the gastro-intestinal tract, such as vomiting, cramps in the stomach, and diarrhœa, sometimes choleraic in character. In severe cases the prostration is great, and occasionally an urticarial or erythematous rash appears on the skin.

(3) Some kinds of fish, especially in warm weather and in hot climates, have been known to produce very severe symptoms. Thus, cases of acute urticaria, with swelling of the tongue, fauces, and eyelids, are frequently due to eating lobsters, crabs, or shell-fish; while gastro-intestinal irritation, sometimes of almost choleraic intensity, is by no means a rare consequence of eating putrid fish of any kind, no doubt due to the poisonous alkaloids developed by the microbes of putrefaction. It has also been observed that in dogs, more especially at sea-side resorts, septic forms of poisoning and choleraic conditions are more frequently produced by the devouring of putrid fish than by any other kind of animal matter. The disease known by the Spanish name of *siguatera* is of this description, and is common amongst the crews of vessels doing duty in the tropics when they partake of fish caught at the various stations as a change from the ordinary diet of the ship.

Reference should here be made to the numerous outbreaks of enteric fever which have recently been traced to the consumption of sewage-contaminated oysters, and it is highly probable that other shell-fish which feed on sewage-polluted beds contribute materially in spreading the disease. It has also to be noted that a great majority of the sporadic cases of cholera which occurred in the autumn of 1893 were traced to the consumption of oysters obtained from a cholera-infected port on the east coast (see *Reports on Cholera to Local Government Board*, 1894). Further, the extremely foul conditions under which edible molluscs are fed and fattened are fully set forth in Dr. Bulstrode's report submitted to the Local Government Board in 1896.

3. *Unwholesome Vegetable Food.*—As regards foods of this description it may be said that all articles which have become mouldy or partially decomposed are dangerous. Vegetables and fruits coming under this category should be condemned. On the Continent the ergot of rye has been productive of serious epidemics, and in this country alarming symptoms have frequently followed the use of flour which contains the ground seeds of *Lolium temulentum* or darnel. Flour which has a strong musty flavour should be condemned, and if dark in colour it should be examined microscopically.

Section VII.—Milk in its Relation to Disease

Although the relationship between milk and disease was clearly established as far back as 1870, the numerous outbreaks of milk-borne diseases which have since been recorded, illustrate with increasing forcibleness the serious and often hidden dangers which still attach to our milk supplies in spite of the protection afforded by recent legislation.

In a paper read before the International Medical Congress in 1881, Mr. Ernest Hart gave a tabulated account of as many as 71 outbreaks of diseases due to the agency of milk, namely, 50 of enteric fever, 14 of scarlatina, and 7 of diphtheria; while the number of cases traceable to each of these diseases in the various outbreaks was estimated at 3500, 800, and 500 respectively. As regards enteric fever, the contamination of the milk was, in 22 out of the 50 outbreaks, traced to the use of specifically polluted water for "washing the milk-cans," and no doubt in all of them the water was the prime agent in producing the disease. In the majority of outbreaks of scarlatina, however, it was found that persons employed in the dairy were in attendance on patients suffering from the disease, or that the disease itself had attacked those employed in the dairy. That paper was published in the Transactions of the Congress, and at once became a mine of reference for writers on the subject, and

no doubt paved the way to the passing of "The Dairies, Cow-sheds, and Milkshops Order" of 1885 (see Chap. XIX). Since that date, the addition to the literature of milk-borne disease has been greatly extended, and more particularly in the recognition of the fact that a diseased condition of the cow herself is the direct cause of the infective quality of her milk. In this direction, the elaborate and painstaking inquiries of Mr. Power, F.R.S., Senior Assistant Medical Officer of the Local Government Board, and especially his report on the Hendon outbreak of 1885, aroused so much attention at the time that they may be said to have marked an epoch in epidemiology, and have since received ample illustration in other reports, notably those of Dr. Parsons of the Local Government Board, and Dr. Russell, Medical Officer of Health for Glasgow. These detailed reports received further elucidation by the bacteriological researches of Dr. Klein, and on the face of them Dr. Klein's biological tests seemed to confirm the contention that in respect to scarlatina and diphtheria there is direct casual relationship between morbid conditions of the cow and the human subject.

Quite recently, Mr. Ernest Hart has prepared a report which appeared in the *British Medical Journal* on 8th, 15th, and 22nd May 1897. This report constitutes a most valuable supplement to his paper of 1881, inasmuch as it may be regarded as a complete history of milk-borne infectious diseases since that date. In the abstract which accompanies the report he gives particulars of 32 outbreaks of scarlatina, 15 of diphtheria and allied sore-throat ailments, and 48 of typhoid fever. Except in one or two instances, all of these outbreaks occurred in the United Kingdom, and though many so-called milk outbreaks were collected, and many more which escaped notice, because no particulars were received for publication, "only those have been included which appeared to bear the light of close investigation upon them as to milk being the *vera causa* of the particular epidemic." Apart from the detailed particulars of the outbreaks themselves, which are rendered all the more valuable

by the reference in all instances to sources of information, the abstract is accompanied by a still more valuable commentary, dealing not only with the various circumstances and conditions in which milk may become infected, but pointing out succinctly the lines on which further legislation should be based to safeguard our milk supplies more securely.

But, before dealing with specific milk outbreaks, it will be of advantage to consider very briefly the particular characteristics of milk which qualify it in such an exceptional degree as an agency in the spread of disease. And in the first place it has to be noted that milk is highly absorbent, and therefore becomes readily tainted with any gases or vapours, whether organic or inorganic, or any noxious effluvia to which it may be exposed, such as the foul smells from manure-heaps, middens, or drains, or the foul close air of a dirty-kept dairy or pantry. It then presents the taste and smell of the absorbed impurity, rapidly decomposes, and has often been the cause of gastric irritation, vomiting, and diarrhœa.

But as an absorbent it also becomes readily impregnated with any filth from the hands of dirty milkers, from dirty teats, or from imperfectly cleansed vessels in which it may be conveyed or stored. Further, lead, copper, and zinc may be absorbed by milk from the vessels in which it is allowed to stand, and so appreciable is this danger that in Würtemberg the use of zinc and copper utensils is absolutely prohibited. Enamelled earthenware which contains lead carbonate is objectionable, because it can be attacked by milk which has become sour. Tin, or tinned iron, is preferable, but enamelled iron pans are safer still.

Filth-tainted milk rapidly decomposes, and if the *oidium albicans* is present it may induce thrush in infants, while other fungi, such as penicillium, aspergillus, etc., may cause gastric irritation. This tainting of the milk is notoriously exemplified in the prevalence of infantile diarrhœa during warm weather owing to the negligence in keeping feeding-bottles clean, and it is highly probable that this intestinal

irritation is largely due to the formation of tyrotoxicon by decomposition of the milk in the gastro-intestinal tract.

In the second place, as milk is a liquid which contains all the essential constituents of food, it forms a typical medium for the cultivation of bacteria, and it is therefore maintained that disease germs which have gained access to the milk may in a very short time multiply to such an extent as to greatly increase its power of infectivity. Many of the recorded outbreaks, more especially of scarlatina and enteric fever, support this view.

As to ways in which milk may become infected in addition to those already alluded to, it may also become infected with the germs of animal disease—as from the mouth discharge of a neighbouring cow suffering from foot-and-mouth disease, or, as has occasionally happened, from the nasal discharge of a horse suffering from strangles, put up in the same outhouse. There is reason to believe too, that symptoms of a diphtheritic nature have been induced by using milk obtained from a cow which the calf was allowed to suckle, when the calf itself was suffering from throat symptoms.

In respect to milk viewed as a secretion, it is evident that it must always in some degree reflect the health condition of the animal for the time being. In the Western States of America the milk of cows affected with "the trembles" from eating the leaves of the *rhus toxicodendron*, or poison oak, has frequently been known to produce severe gastric symptoms among children, accompanied by great weakness and lowering of the temperature, and sometimes proving fatal. In France, where feeding-bottles are so largely used, a sudden and great increase of infantile diarrhœa and allied disorders was observed to follow the establishment of a large brewery in a certain district, and the cause was found to be the use of "brewers' grains." Indeed in America *swill milk*, as it is called, or milk obtained from cows fed on distillery swill, is regarded as such an unwholesome food for children that its sale is prohibited by law. Then, again, it is hardly necessary to point out the

risk of using milk from a cow under medicine, because, apart from the diseased condition of the cow, it is well known that all soluble salts may appear in the lacteal secretion.

Although it may be quite true that the milk of diseased cows is often used without producing any appreciable ill effects, there is always a great element of danger, and on that account it cannot be too strongly insisted on that milk yielded by a cow suffering from any form of disease, and especially from a diseased condition of the udder and teats should be condemned for food. Whether the disease be constitutional or local—a mere rise of temperature, or some casting of the hair or cuticle, a chapped teat, or some pustular or vesicular eruption—the only safe rule for the dairyman to follow is to exclude the milk from the common stock.

The milk of cows suffering from *foot-and-mouth disease*, according to Sir Richard Thorne, F.R.S., sometimes produces aphthous ulceration of the mouth and gums, with swelling of the tongue and great fœtor of the breath, and several outbreaks of this kind have been recorded. In *anthrax* and *anthracoid diseases*, the specific bacilli have been found in the milk, while the milk itself is of a bad colour, contains pus or blood cells, and rapidly decomposes. Then, again, in cases of inflammation of the udder or teats, *staphylococci* and probably *streptococci*, according to Lehmann of Würzburg, become mixed with the milk, and the ingestion of milk with which cultures of staphylococci had been mixed, has proved fatal to rabbits in about one-fourth of the cases.

In respect to *tuberculosis*, it is notorious that stall-fed cows suffer in large numbers from this disease, and some of them from tuberculous nodules in the udders, which often suppurate. In tuberculosis, nutrition is not much interfered with until the disease reaches an advanced stage, and even then, the amount of milk yielded, though poor in quality, is so plentiful that the dairyman keeps the animal, and mixes the milk in the general stock.

The dangers attaching to milk obtained from cows suffering from this disease, apart altogether from any implication of the teats or udders, are based on the fact that the bacilli of bovine tuberculosis are identical with those found in the human organs, although the disease presents different anatomical conditions in man and cattle.

According to the experiments, more especially of Martin, Galtier, and Bang of Copenhagen, milk which is found to contain tuberculosis bacilli produces the disease either by ingestion when injected into the peritoneum of guinea-pigs, or by inoculation, and this also applies to cream, butter, and whey.

It is also well known that pigs fed on dairy refuse are sometimes infected with tuberculosis of a most typical kind, and Dr. Sims Woodhead, the well-known bacteriologist, has recorded an outbreak among these animals which could be distinctly traced to the milk of three cows which were found to be suffering from marked tubercular mammitis.

In the *International Journal of the Medical Sciences* for November 1889, Dr. Ernst of Boston has summarised the conclusions which he has drawn from a most careful experimental investigation conducted under the auspices of the Massachusetts Agricultural Society in the following propositions: "1st and emphatically, That the milk from cows affected with tuberculosis in any part of the body may contain the virus of the disease. 2nd, That the virus is present whether there is disease of the udder or not. 3rd, That there is no ground for the assertion that there must be a lesion of the udder before the milk can contain the infection of tuberculosis. 4th, That, on the contrary, the bacilli of tuberculosis are present and active, in a very large proportion of cases, in the milk of cows affected with tuberculosis, but with no discoverable lesions of the udder."

To all this the objection has been raised that if all tuberculous cattle yielded tuberculous milk, the disease would be far more common amongst human beings than it really is; but the experiments of Koch and others

on anthrax and cholera bacilli, when ingested, largely support the contention that it is only when the intestinal functions are interfered with, and when, in consequence, there are alterations in the structure and in the chemical constituents of the fluids of the alimentary canal, that tubercular bacilli can penetrate through the epithelial layer.

According to Lehmann and other German authorities, mixed milk, as usually purchased, is generally harmless, so far as the spread of tuberculosis is concerned.

Coming now to the consideration of milk in relation to special zymotic diseases, it should be noted that several of the most important inquiries, and more particularly those by Mr. Power and Dr. Parsons, illustrate the great danger attaching to the consumption of milk from newly calved cows, even when it is mixed with large quantities of milk obtained from healthy cows. And this can be well understood, for not only is there risk owing to inflammatory processes which may set in after parturition, but there is the further risk of vaginal discharge finding entrance into the milk. It is also noteworthy that in several of these outbreaks the milk presented a peculiar "ropy" appearance, no doubt due to microbial action.

As regards other morbid conditions of the cow which directly infect the milk, the frequency with which vesicular and pustular eruptions on the teats and udders have been observed, has led to the view, first enunciated by Mr. Power, and supported by the bacteriological researches of Dr. Klein, that there is an eruptive disease of the cow which is identical with scarlatina in man, and which is communicable to man through the agency of milk. In subsequent inquiries, however, similar eruptive conditions of teats and udders have been regarded as the exciting cause of milk-borne diphtheria, and even of milk-borne typhoid fever; but in order to set forth more clearly the various views which have been entertained, and the controversial points which have been raised in respect to the precise etiology of some of these much-debated outbreaks, it will be of service to discuss them more fully in detail.

1. *Scarlatina.*—(1) Although the great majority of milk scarlatinal outbreaks have been traced to human infection, the well-known outbreak at Hendon, Wimbledon, and the North of London, in December 1885 served to show that cows are liable to a disease identical with, or very closely resembling, human scarlatina. This outbreak was investigated by Mr. Power, and the experimental researches which it opened up were conducted by Dr. Klein. There was no doubt at all that the outbreak was due to the milk supplied by the Hendon cows; that a certain number of the cows were found to be suffering at the time, or had been suffering, from vesicles or ulcers upon the teats and udders; that this eruption was infectious; and, further, that it had been first seen on a cow which had been purchased on 15th November. (See *Report of Medical Officer to Local Government Board* for 1885-86.)

The results and conclusions derivable from Mr. Power's inquiry and Dr. Klein's researches are best summarised in the words of the late Sir George Buchanan in his report to the Local Government Board for 1886-87 :—

"The disease in man and in the cow alike is characterised by closely similar anatomical features.

"From the diseased tissues and organs of man and cow alike the same micrococcus can be separated, and artificial subcultures be made from it.

"These subcultures, no matter whether established from man or cow, have the property, when inoculated into calves, of producing in them every manifestation of the Hendon disease, except sores on the teats and udders; no doubt for the reason that the milk apparatus is not yet developed in calves.

"But — and this I learn from Dr. Klein's later observations while this report is in preparation—the subcultures made from human scarlatina and inoculated into recently calved cows, can produce *in those cows*, along with other manifestations of the Hendon disease, *the characteristic ulcers on the teats*—ulcers identical in character with those observed at the Hendon farm.

"The subcultures, established either from the human or the cow disease, have an identical property of producing in various rodents a disease similar in its pathological manifestations to the Hendon disease of cows and to scarlatina in the human subject.

"Calves fed on subcultures established from human scarlatina obtain the Hendon disease.

"Children fed on milk from cows suffering under the Hendon disease obtain scarlatina.

"The above combine, I think, to form a mass of evidence to show that the Hendon disease is a form, occurring in the cow, of the very disease that we call *scarlatina* when it occurs in the human subject."

(2) Another outbreak of scarlatina, associated with diphtheria and sore throat, which occurred at Macclesfield and Upton in February 1889, may be placed in the same category. This outbreak was investigated by Dr. Parsons, and though in this instance the cows of the implicated dairy were certified to be healthy by competent veterinary authorities, it was made clear that the milk of a newly calved cow, which had been recently purchased, was mixed three days after calving with the other milk sold on 23rd January, the date of the outbreak; that this cow, while it showed no "chaps on teats," had a few bare patches on both rumps, around which the skin was scurfy and the hair could be easily pulled out. Another cow, which was purchased on the same date, namely, on 14th January, and which had calved three days previously, had also many bare patches on the neck and a few on the back and rump, while several of the other cows in the same shed had similar patches, but no sores or scabs on the udders or teats. The outbreak continued in operation from 23rd January to 31st January, when the implicated milk-supply was stopped. But it is very significant that on the occurrence of fresh cases of illness in the same milk-run on 15th March the milk from the first cow mentioned, which calved on 20th January, was excluded from the general stock, because it was found that in the early part of March some pimples or

vesicles developed on one of the teats of this cow, and at the time her milk was rejected, scabs had formed on these. On Dr. Parsons' second visit on 25th March, he found a thin adherent scab about the size of a sixpence near the lower part of one teat. The teat felt sticky, and the milk flowed less readily from it than from the others, and had to be drawn off with a quill. The cow had lost flesh.

The peculiar features of this outbreak consisted in the mixture of scarlatinal, diphtheritic, and sore-throat, cases; the frequency of vomiting and purging at the commencement; the sudden onset of the illness; the ill-defined character of the rash when it appeared; the scanty desquamation; the slight tendency to spread by infection; the absence of kidney symptoms; and the doubt entertained by the medical attendants that the cases which presented a rash were true scarlatinal cases, but rather cases of some form of blood-poisoning. (See *Report of Medical Officer of Local Government Board*, 1889.)

(3) Dr. Bostock Hill, Medical Officer of Health for Sutton Coldfield, investigated an outbreak of scarlatina which occurred in that district in the early part of 1891. The exciting cause is thus given in Mr. Ernest Hart's abstract: "One cow recently calved, much emaciated, with some indication of recent ulceration on teats. Later she had extensive patches of desquamation, an ulcer on one teat, and an eruption on the udder. Appearances those of Hendon outbreak of 1885. A second cow presenting slight indications of same condition." (See *Brit. Med. Journal*, 15th May 1897.)

(4) In respect to an outbreak at Charlton in March and April 1892, which was investigated by Dr. Hamer, Assistant Medical Officer of the London County Council, the exciting cause is stated to be:—"Illness of one cow, milk ropy, severe cold, udder and teats presented scabs and excoriations." (See as above.)

(5) Outbreak in Glasgow, August 1892. The abstract of this outbreak is quoted in full, not only on account of the special interest attaching to it, but to illustrate briefly the

detailed particulars which an inquiry into a milk outbreak should embrace.

Date of Outbreak: August, 1892. *Reporters:* Drs. Russell and Chalmers. *Total Number of Cases:* 236. *Deaths:* 11. *Number of Cases amongst Drinkers of Suspected Milk:* 236. *Percentage to Total Cases:* 100. *Number of Families Supplied by Milkman:* 359 + ? *Number of such Families Invaded:* 152.

Sanitary Circumstances of Farm or Dairy from which the Milk was derived.—All that could be desired.

Exciting Cause of Outbreak.—Ulcerative eruption on the udders and teats of the cattle—vesicular, quasi-pustular in form, crusted with blackened centre. Such are some of the terms applied to the affection, which was communicable by some means from cow to cow and from shed to shed. Sores also formed on the hands of some of the milkers. Condition of teats only discovered on cows becoming restive under action of being milked. Dr. Klein found the disease in these milch cows to be allied in some points to that in the Hendon and Camberwell milk-borne epidemics.

Circumstances implicating Milk.—Disease incidence confined to the milk service of one dairy getting milk from two farms. Milk from the implicated farm mostly used on first morning round, 57 families and 91 individuals being attacked out of 193 families supplied on this round. The mixed milk always used on second round, and 59 individuals in 37 (out of 166) families attacked thereon. The counter trade mostly with the implicated milk, 86 persons in 58 families being attacked. Some of the unsuspected milk was transferred each day to another dairy during part of the epidemic period. No cases of scarlet fever occurred in the customers of the dairy so served. The suspected milk was stopped on 7th August. No cases traceable directly to the agency of the milk occurred later than 20th August.

Facts showing Special Incidence of Disease.—In one street 21 families (more than half those supplied with the milk) yielded 29 cases; some streets taking the milk suffered no attacks. The active principle of contagion thus apparently not uniformly distributed.

Reference.—Special Report of Medical Officer of Health. (See as above.)

2. *Diphtheria.*—An inflammatory condition of the udder, known as *garget*, has been suspected of causing diphtheria in those using the milk, and Mr. Power, in a report presented to the Local Government Board as far back as 1878 on an outbreak of diphtheria in North London, was led to the conclusion that this might have induced the disease. Although this view has not been clearly established by subsequent

inquiries, there are several outbreaks recorded in which morbid conditions of teats or udders have been believed to be the exciting cause :—

(1) In the well-known outbreak of diphtheria which occurred at York Town and Camberley in 1886, and which was most carefully investigated by Mr. Power, it was clearly proved that, though no human source of infection could be traced, the ability of the implicated milk to cause diphtheria was pronounced and persistent day by day from the 8th to the 18th of October. The whole of the evidence made it also clear that the milk had become infected before leaving the farm where it was produced, but the conclusion arrived at was to the effect that the method of infection of the milk was not demonstrable in the existing state of knowledge on the subject. During the course of the inquiry, however, there was this interesting fact elicited, that a veterinary surgeon, on examining the cows in the implicated dairy, found that though all the cows were healthy, two cows showed signs of chaps in their teats, and further, that at the beginning of November one cow, "which had suffered from chapped teats, still had, at the site of a chap, a scab or crust, not unlike those which at a later stage of their malady had been observed to replace ulcers on the udders of certain Hendon cows." (*Report of Medical Officer to Local Government Board.*)

(2) At Croydon, in October 1890, Dr. Philpot, Medical Officer of Health, investigated an outbreak of diphtheria, in which the total number of cases amounted to 191, and the deaths to 38. In this outbreak the exciting cause was believed to be "teat eruptions in cows, stated by Dr. Klein to be similar to those met with in diphtheria outbreaks traced to milk of diseased cows." (*Brit. Med. Journal*, May 1897.)

(3) The abstract of the following outbreak which occurred in Glasgow is quoted in full from Mr. Ernest Hart's report already referred to :—

Date of Outbreak: August 1892. *Reporter:* Dr. Russell, M.O.H.
Total Number of Cases: 224.
Sanitary Circumstances of Farm or Dairy from which the Milk was

derived.—Business at both dairy and farm conducted with scrupulous attention to cleanliness. No insanitary conditions present.

Exciting Cause of Outbreak.—Nearly all of a herd of 53 cows suffered from teat eruptions, small in beginning, but leading to ulceration. Ulcers yielding faintly-coloured fluid; three or four on one teat; sometimes all teats affected. "Hendon" streptococcus isolated from lymph, as proved by growth, and inoculation into mice. Two varieties of eruption in question shown by experiments on calves with scabs from ulcers, one being true vaccinia, the other a non-vesicular eruption of a specific character like that of "Camberwell" outbreak. No suggestion of desquamation or evidence of constitutional disturbance in cattle, as observed in Hendon and Camberwell cases. Farmer and three other milkers had eruptive sores on hands, one being compelled to stop work.

Circumstances implicating Milk.—Between 6th and 8th August from 60 to 70 cases notified. Milk-supply stopped on 8th; cases ceased on 12th. On latter date all cattle seemingly recovered separated from rest, and milk sold unmixed from 23rd till 30th, when supply again stopped. Cases cropped up on 25th and occurred daily till 8th September, all among consumers of this milk.

Reference.—*British Medical Journal*, vol. ii. 1892, pp. 432, 666; vol. i. 1893, p. 35.

(4) In an outbreak at Finchley in November 1894, investigated by Dr. Kenwood, Medical Officer of Health, the exciting cause is stated to have been:—"Three cows supplying the milk had diseased teats, and one had a chronic abscess of the udder." (*Brit. Med. Journal*, May 1897.)

But apart from outbreaks presenting more or less diphtheritic symptoms, certain obscure throat affections have been traced to a tainted milk-supply, and notably an outbreak which occurred in Aberdeen in 1881. In this outbreak the sufferers were attacked by severe rigors, followed by febrile symptoms and extreme prostration. The tonsils were slightly enlarged, but there was no false membrane, while a marked feature was the swelling of the glands of the neck, and those above the clavicle. Over 300 persons sickened within a short time, and 90 families were attacked out of a total of 110 supplied by the same dairy. So soon as the milk-supply was stopped, the further spread of the disease was at once arrested; indeed, its disappearance was as sudden as its onset. In this instance the water-supply was obtained from an uncovered cistern in the cow-

shed, and on analysis it was found to be polluted ; but though suspicion attached to the water, the abruptness of the outbreak points rather to some temporary tainting agency which was not discovered, although it was found to be connected with minute organisms in the milk. (*Sanitary Record*, 1881.)

Although the outbreaks of diphtheria attributed to milk supplies which have been recorded are comparatively few, it is interesting to note that in a considerable number of them the precise circumstances implicating the milk were not ascertained, while as regards others, insanitary conditions at the dairy were found in close relation with the milk, either in the form of untrapped drains, dirty milk-cans, dirty linen about the cans, dirty cloths for wiping the cans, or polluted water. Indeed, in reading the accounts of many of these outbreaks, one cannot help being impressed with the references to drains which are not properly disconnected, but which are either untrapped or open, and in such a position as to discharge their effluvia over the milk-vessels or the milk. These are just the conditions which are so frequently found to be associated with localised outbreaks of diphtheria or diphtheritic sore throat, and they suggest pollution of the milk in this way. It is quite probable, too, that milk may become specifically polluted by the breath of the milker, should the milker be suffering at the time from diphtheritic throat, and further, as already stated, there are strong presumptive grounds for believing that the milk of cows, which calves suffering from throat affections are occasionally allowed to suckle, may induce diphtheritic symptoms in those using the milk.

In commenting very briefly upon the above detailed outbreaks of milk-borne scarlatina and diphtheria, it cannot be maintained so indisputably now, as was at first believed, that the eruptive appearances on the teats and udders of cows contributing to the implicated milk are conclusive evidence that a certain eruptive disease of the cow is identical with scarlatina in the human subject. For in the first place it is clear that the same eruptive appearances in

cows have been asserted as constituting the *vera causa* of both scarlatina and diphtheria, as well as ill-defined sore-throat; and in the second place, as notably in the Upton and Macclesfield outbreak (see Scarlatina, No. 2), the symptoms induced in the consumers of the milk were by no means absolutely characteristic of either scarlatina or diphtheria. Then, too, it should be observed that in almost all of these outbreaks the diagnosis of the medical attendants was necessarily accepted as strictly accurate, and this especially holds true in respect to Local Government Board inquiries, because such inquiries cannot take place until after varying intervals, and when characteristic symptoms have mostly disappeared. Septic rashes in cases of blood-poisoning are not at all uncommon, and might readily be mistaken for scarlatinal rashes when there is a sudden outburst of milk-borne disease presenting throat complications. Indeed, Mr. Power has himself stated that, in scarlatinal outbreaks, the type of disease is generally mild and the mortality low.

However, it is but fair to state that in respect to the Hendon outbreak the views of the Medical Department of the Local Government Board were strongly contested at the time by the Veterinary Department, and by several eminent bacteriologists;—the former holding that a possible human source of the disease at Hendon was not excluded, and that other cows which had the Hendon disease did not give rise to any scarlatinal outbreak; whilst among the latter Professor Crookshank maintained that a disease of cows in Wiltshire, presenting all the features of the Hendon disease, was in reality cow-pox, and that the *micrococcus scarlatinæ* described by Dr. Klein was merely the *streptococcus pyogenes* whose relation to scarlatina was definitely established by Fränkel and Freudenberg in 1885.

In connection with Prof. Crookshank's contention, it is important to observe that in the scarlatinal outbreak in Glasgow in 1892 (see *ante* p. 77), the ulcerative eruption on the teats and udders of the cows was associated with "sores which formed on the hands of some of the milkers"; and that in respect to the Glasgow diphtheria outbreak

(see *ante* p. 79), Dr. Klein isolated the "Hendon" streptococcus from lymph obtained from the teats, and further induced "two varieties of eruption by experiments on calves with scabs from ulcers, one being true vaccinia, and the other a non-vesicular eruption of a specific character like that of the Camberwell eruption."

Although the greatest significance attaches to Dr. Klein's researches in connection with these obscure outbreaks of milk-borne scarlatina and diphtheria, practical sanitarians argue that if these diseases are genuine bovine diseases, which as such are communicable to man, how comes it that the outbreaks recorded have been so comparatively few and in a measure so inconclusive? Then, too, there is the fact that bacteriologists do not agree as to the special characteristics of the so-called pathogenic microbe of scarlatina, or the inferences which should be drawn from the *post-mortem* appearances exhibited by animals which have been inoculated either with matter obtained from the assumed specific eruption or with subcultures developed from this material,—some regarding these appearances as the manifestations of simple pyæmic or septic poisoning. Many competent authorities, therefore, still hold the opinion that until more facts are accumulated on which bacteriologists are agreed, it is desirable to reserve judgment.

But whether these milk-borne outbreaks be regarded as scarlatinal, diphtheritic, or essentially septicæmic as seems probable, there can be no question as to the intimate causal relation between morbid cow conditions and human infectious disease.

3. *Enteric Fever.*—Out of the fifty milk-borne outbreaks of enteric fever recorded by Mr. Ernest Hart in his 1881 paper, and of the forty-eight additional outbreaks which appear in his 1897 report, about one-half the total number were traced to specifically polluted water, and probably in all of them polluted water used either for rinsing the milk-cans or diluting the milk was the prime agent in producing the disease. In only one, namely, an outbreak in Dundee in 1889, was the exciting cause reported to be "eruptive

disease on the teats of a newly calved cow," but in this instance the drainage of the dairy was also found to be defective. In three outbreaks in the South of Ireland, the disease was traced to milk tainted with specifically polluted water which had been mixed with other milk at creameries.

Included in Mr. Ernest Hart's abstract is a somewhat unique outbreak of enteric fever which occurred in Greenwich and Rotherhithe in the autumn of 1892. This was investigated by Dr. George Turner, now Medical Officer of Health for Cape Colony, who attributed it to "specific contamination of ice-cream sold at street barrows by Italian vendors; and brought about probably by sewer emanations, polluted water, or by the milk used."

In a very few exceptional instances, the disease was believed to have been originated by the drinking of polluted water by the cows themselves, and it has also been maintained that enteric symptoms in the cow may induce enteric fever in consumers of her milk, but so far the evidence in support of these views does not appear to be conclusive. Nor is there any evidence to show that the milk or butter of cows fed on sewaged grass, as was at one time feared, has produced typhoid fever or other ill-effects; on the contrary, numerous analyses have proved that the milk and butter obtained from cows so fed are of excellent quality and keep well.

4. *Cholera.*—It is highly probable that milk tainted with polluted water plays an important part in the spread of cholera in India, and the following is of interest:—Dr. Simpson, Medical Officer of Health for Calcutta, recorded in his report for 1887 particulars of a slight outbreak which occurred on board a ship lying in harbour, resulting in nine cases and four deaths, in which the specific contagion seemed undoubtedly to have been conveyed by milk. In this instance it was clearly ascertained that, excluding all other possible causes, the native milkman who supplied the milk confessed to habitually diluting his milk with water from a tank into which dejecta from a cholera patient found access.

The special characteristics of milk epidemics, and

particularly those of scarlatinal or throat types are—the usually sudden outbreak and its almost equally sudden cessation, when due allowance is made for late cases in infected households; the large proportion of attacks which are simultaneous or nearly so; and the very large proportion of households attacked which will be found to have a common milk-supply, though the milk may not be distributed by the same retailer. It will also be found that if the households are classified according to the amount of milk supplied by the suspected dairy, the invasions will be proportionately more numerous in those using larger quantities; and hence the great incidence of the disease generally falls on households of the better class. This also applies to individuals, and therefore the attacks are more numerous among children and women than among men. In respect to outbreaks of enteric fever this would be specially significant, because under ordinary conditions the disease chiefly affects adults.

When an outbreak, which is suspected to have a milk origin, occurs in any locality, and the exact source of infection has not been traced, it is always advisable to recommend the consumers to boil the milk. So soon, however, as suspicion falls on any dairy, the employees, cows, premises, water-supply, etc., should be carefully examined, and if the Health Officer has reason to believe that the milk-supply is implicated it should forthwith be prohibited until the source of infection is removed or other sufficient precautions are taken (see Chapter XIX.)

The effects of milk preservatives on health, such as boric acid, formaldehyde, or salicylic acid, have not been clearly established, but it may be said generally that if milk is properly cooled or sterilised, and vessels kept properly clean, such sophistication is entirely unnecessary, and is always undesirable, and unjustifiable.

CHAPTER III

AIR: ITS IMPURITIES, AND THEIR EFFECTS ON PUBLIC HEALTH

SECTION I.—COMPOSITION

THE average composition of pure atmospheric air per cent by volume and by weight is as follows:—

	By volume.	By weight.
Oxygen	20·96	23·10
Nitrogen	79·00	76·84
Carbonic acid (carbon dioxide)	·04	0·06
Ozone, mineral salts, and organic matters	traces.	
Ammonia and watery vapour	variable.	

With the exception of carbonic acid and aqueous vapour, the relative proportions of the other constituents remain tolerably constant throughout the globe. According to the late Dr. Angus Smith, the amount of oxygen varies from 20·99 per cent in the sea air of the west of Scotland to 20·91 in Manchester during frost and fog, while the carbonic acid ranges from ·03 to ·05 per cent. Indeed, in the close courts and narrow streets of Manchester and London, where the atmosphere is stagnant, the air may contain only 20·80 per cent of oxygen, and even less, while the carbonic acid may exceed ·06 per cent. Both the carbonic acid and organic matters increase as we pass from rural districts to the suburbs of a town, and from the suburbs to more thickly-populated parts; but the former varies much less than the latter.

The amount of aqueous vapour fluctuates greatly, and is mainly influenced by temperature. At a given tempera-

ture, air cannot contain more than a certain quantity of moisture in suspension, and when it has taken up this quantity it is said to be saturated. In general, the air contains from 50 to 75 per cent of the amount requisite for complete saturation, the average amount being about 1·46 in 100 parts. If the quantity be not within these limits, the air is either unpleasantly dry or moist.

The ammonia, which exists as carbonate, chloride, sulphate, or sulphide, is present only in very minute quantities, and does not exceed one part in a million parts of air. Its variations are generally, though not always, found to accord with those of carbonic acid.

In addition to these ingredients, ozone may perhaps be reckoned as a normal constituent, though it is generally absent in town air, and spectroscopic analysis has shown that the salts of sodium are everywhere present in greater or less abundance.

Section II.—Impurities in Air, and their effects on Public Health

Preliminary Remarks.—Impurities in air may be roughly divided into suspended and gaseous matters. While the presence of suspended matters is rendered familiar to every one in the shining particles which become visible in the direct rays of the sun, the well-known demonstrations by the late Professor Tyndall with the electric light showed, perhaps more forcibly than hitherto, their almost universal diffusion. Particles of silica and silicates, of calcium carbonates and phosphates, of iron salts, and, in short, of every chemical constituent of the soil, are lifted by the winds and carried hither and thither. In inhabited places, carbon particles, hairs, fibres of cotton, wool, and other fabrics, starch-cells, etc., are found in great abundance. From the vegetable world are wafted seeds and the *débris* of vegetation, as well as the spores of various fungi and moulds, monads, pollen, and volatile substances. In like manner, the animal kingdom supplies putrid substances, and par-

ticles of decayed or decaying tissues, such as epithelium and pus cells with their accompanying micro-organisms.

Microbes in air vary enormously according to locality and meteorological conditions. Dr. Miguel of Paris found that the average number per cubic metre of air was 455 in the Park of Montsouris, and 3910 in the Rue de Rivoli—these numbers representing the mean of six years' observations from month to month. He also found that the seasonal maximum occurred about midsummer, and the minimum about Christmas. Micrococci constituted 60 per cent of these bacteriform organisms, and the remainder consisted of bacilli and true bacteria.

The numerous gaseous matters which pass into the atmosphere, and render it impure, will be more conveniently noticed in the subsequent remarks concerning overcrowding, and the injurious effects of different trades and manufactures.

In towns the amount of organic matters and mineral dust will depend greatly on the ventilation of thoroughfares, and on the efficiency of the scavenging and watering of the streets. The wind raises minute particles from the surfaces, and often carries them far distances before they are deposited. In this way the air becomes the vehicle not only for mineral matters, but for pathogenic microbes and foul effluvia from dust-heaps, middens, and other filth accumulations. Indeed, were it not for the purifying agencies of the atmosphere, which are constantly at work, healthy existence would become impossible. Winds, however, and the ordinary movements of air sweep away impurities and bring pure air in their place; injurious gases become diffused, diluted, or decomposed; animal emanations, are absorbed in the processes of vegetation; suspended matters are washed down by the rains, or fall by their own weight; while many organic substances are oxidised, and thus rendered innocuous. Were it not for these purifying agencies, which are in constant activity, sanitary measures would prove futile; and, indeed, they are only successful in so far as they approximate to the preventive and remedial means which Nature employs.

1. *Air vitiated by Respiration.*—A healthy average-sized adult at rest breathes at the rate of 17 respirations per minute, and at each respiration about 30·5 cubic inches of air pass in and out of his lungs. The composition of the respired air is roughly as follows:—Oxygen, 16·96 per cent; nitrogen, 79·00 per cent; and carbonic acid, 4·04 per cent, together with watery vapour and certain undefined organic substances. In other words, the air in the lungs loses on the average 4 per cent of oxygen and gains 4 per cent of carbonic acid, while the nitrogen remains unchanged.

The amount of carbonic acid which is given off by an adult, as calculated from the above figures, will therefore be about 0·72 cubic feet per hour. According to Pettenkofer, this amount is increased by exertion in the following proportion:—In repose, 2; during gentle exercise, 3; and at hard work, 6. In both sexes the amount increases up to about the thirtieth year, but beyond the eighth year the exhalation is greater in males than in females. When applied to a mixed community of adults of both sexes the average amount exhaled by an adult during the twenty-four hours has been estimated by Parkes as 16 cubic feet, or about 0·6 cubic feet per hour, and this is the figure which is usually taken as the basis of all calculations on ventilation and air-supply.

The quantity of watery vapour thrown off by the skin and lungs varies according to the individual and the hygrometric condition of the atmosphere. It has been estimated at from 25 to 40 oz. in the twenty-four hours, and requires, on the average, 210 cubic feet of air per hour to retain it in a state of vapour.

The organic matter given off has never been accurately determined. It has a very fœtid smell, and is but slowly oxidised. It is believed to be molecular, and may be said to hang about a room like clouds of tobacco-smoke, and, like tobacco-smoke, the odour is difficult to be got rid off, even after free ventilation has been resorted to. It darkens sulphuric acid, and decolorises solutions of potassium permanganate. When drawn through pure water it renders

it very offensive. It is certainly nitrogenous, and probably in combination with water, because hygroscopic substances absorb it most readily. It promotes the growth of micro-organisms, and milk, meat, or other food exposed to it rapidly becomes tainted. In sick-rooms it is associated with pus-cells, micro-organisms, and other emanations of disease. As much as 46 per cent of organic matter has been found in plaster taken from the walls of a hospital ward in Paris, and Miguel has estimated the number of microbes in the Hotel de Dieu at 79,000 per cubic metre of air.

According to a report on the air of Glasgow by Dr. Russell and Mr. Dunnachie, published in May 1879, nitrogen, as free and albuminoid ammonia, was found to be always in excess in the two centric stations of observation in the city, when compared with analyses made of the air collected at an eccentric station; but it was also found that the amount of potential or albuminoid ammonia became much lower in the month of July, clearly showing, especially when the amount of sulphur is taken into account, that both forms of ammonia are "largely derivatives of the rapid combustion of fire applied to wood or coal." These experiments have been confirmed to a certain extent by those which have been carried on at the observatory of Montsouris, in the neighbourhood of Paris, and serve to prove that the amount of ammonia cannot be relied on as an index of the insalubrity of air without taking into account the natural history of each sample.

Practically speaking, the amount of organic matter in air vitiated by respiration is found to increase as the carbonic acid increases. According to Parkes it becomes distinctly perceptible to the sense of smell when the carbonic acid in an inhabited room amounts to ·7 per 1000 cubic feet of air—a statement which has been frequently verified by other investigators. This amount, however, is often found to be enormously increased; thus, in seventeen samples of air from public schools in America, Endemann found the carbonic acid varying in amount from ·9 to 3·5 per 1000 cubic feet of space.

Briefly, then, the changes produced in an occupied air-space by respiration and transpiration are the following:—The amount of oxygen is greatly lessened, the carbonic acid and watery vapour are largely increased, ammonia and organic matter are evolved, and suspended matter in the shape of low forms of cell-life and epithelium scales is thrown off.

The effects of breathing considerable quantities of carbonic acid in air otherwise pure have not yet been determined with sufficient accuracy. Angus Smith found that 30 volumes per 1000 cubic feet of air produced great feebleness of the circulation, slowness of the heart's action, and quickened respiration; but he experienced no discomfort in a soda-water manufactory, where the amount was 2 per 1000 volumes. On the other hand, Pettenkofer and Voit found that no discomfort was experienced from long exposure when as much as 10 per 1000 volumes was present. In respired air, however, headache and vertigo are undoubtedly produced in many persons when the carbonic acid exceeds 1·5 per 1000 volumes; but probably this is as much due to the presence of organic effluvia, and the diminution in the quantity of oxygen, as to the increase in the amount of carbonic acid. Yet it must be borne in mind that even a small excess of carbonic acid interferes with healthy physiological action, inasmuch as it prevents the sufficient exhalation of the gas itself, and induces an undue accumulation of it in the blood. In like manner, the quantity of oxygen absorbed is lessened, and there is consequently a retardation of these oxidising processes which are requisite for the complete elimination of effete matters from the system. But while there is always an increase in the amount of carbonic acid, there is likewise, as already pointed out, a marked diminution in the quantity of oxygen in respired air. Thus, Angus Smith found that the percentage of oxygen in the open air of a suburb of Manchester amounted to 20·96; in a sitting-room, to 20·89; in the pit of a theatre, to 20·74; in the Court of Queen's Bench, to 20·65; and in the sumpt of a

mine, to 20·140. It does not follow that, because pain or discomfort is not always experienced in a vitiated atmosphere, no harm has been done. The effects may be slowly and imperceptibly cumulative, but they are none the less injurious, and they are now recognised as being amongst the most potent and widespread of all the "predisposing causes" of disease.

Speedily fatal results, arising from overcrowding and the want of fresh air, are familiar to every student of medicine. Out of the 146 prisoners confined in the "Black Hole of Calcutta," 123 died in one night; and it is significant that many of the survivors afterwards succumbed to "putrid fever." Nor have similar instances been wanting in this country. Of the 150 passengers that were shut up in the cabin of the Irish steamer *Londonderry*, with hatches battened down during a stormy night in 1848, 70 died before morning. No doubt, in these two catastrophes, the direct cause of death was asphyxia; but the fact that "putrid fever" attacked many of those who were carried out alive from the Black Hole of Calcutta showed that the fœtid exhalations to which they were exposed must have aided largely in destroying the lives of the immediate victims. Indeed, it has long been admitted that the rebreathing of fœtid matter thrown off by the skin and lungs produces a kind of putrescence in the blood, in proportion to the amount inhaled and to the period of exposure to its influences.

This view, however, that respired air contains a volatile organic poison, which had long been entertained, and specially emphasised some years ago by the experiments of Brown-Séquard and D'Aronville, has recently been strongly contested by Billings, Weir Mitchell, and Bergey in America. The experiments which they conducted were made on mice, sparrows, guinea-pigs, and rabbits, and were entirely confirmative of the negative results obtained by Hermann, Loze, Haldane, Lorrain Smith, and others. Apart from any effects produced through the sense of smell, they contend that respired air has no action whatever beyond

what is due to excess of carbonic acid or moisture and deficiency of oxygen; and that the effects of the excess of carbonic acid are not appreciable until 3 per cent is present. In accounting for the headache, nausea, and other symptoms induced by a foul overcrowded atmosphere, they assume that these disagreeable effects are largely due to impressions produced through the sense of smell, but this admission surely negatives their whole argument, and whether an alkaloidal poison in respired air is discoverable or not, practical sanitarians can still maintain that the air of an overcrowded room is air vitiated by organic matter, and that the carbonic acid present is a fairly correct index of its injurious qualities. (See *Smithsonian Report* 1895.)

Of this species of poisoning the history of the "Black Assizes," in the sixteenth, seventeenth, and eighteenth centuries, funishes many terrible examples. Jail fever, according to Murchison, was frequently generated *de novo* solely in consequence of the disastrous effects of overcrowding and deficient ventilation, and the disease thus generated often spread from the court-house, where the prisoners were tried, to the surrounding population. Even up till quite recent times, typhus fever was endemic in almost all our large towns owing to the overcrowded and badly ventilated houses of the poorer people.

Of other diseases developed by respired air, there can be no question that *phthisis pulmonalis* holds a prominent place on the list. A large mass of evidence has been collected from various sources bearing on this point, but the fact is now so fully recognised by the medical profession generally that a few instances will suffice. In the celebrated Report of the Army Sanitary Commission, published in 1858, it was proved beyond all doubt that the excessive mortality from consumption amongst soldiers, and in particular regiments, was due to overcrowding and insufficient ventilation. Similar evidence is afforded by the statistics of the Royal Navy, and notably as regards the civil population, in the Report of the Health of Towns Commission, published in 1844. Koch's discovery of the

tubercle bacillus, which is present in the breath and sputa of phthisical patients, affords strong support to the views previously entertained by many that in crowded rooms the disease is not only infectious, but its powers to infect are largely increased. As Ransome of Manchester has pointed out, it is highly probable that the sporulation of the bacillus is greatly assisted by contact with the kind of organic matter found in such atmospheres; but whatever the explanation may be, there can be no doubt that phthisis is intimately associated with overcrowding, deficient ventilation, or the moist effluvia in ground air arising from damp and dirty soils, and that, when these conditions are absent, its capability of propagation is very limited. But in addition to phthisis, other lung affections, such as pneumonia and bronchitis, are generated to a large extent under like conditions, and the same may be said of scrofula, rickets, and other diseases of an adynamic type. In their report to the Local Government Board on back to back houses, the late Dr. Barry and Mr. Gordon Smith showed that there was little doubt that the want of thorough ventilation *per se* gives rise to an increased mortality from phthisis, lung diseases, and diarrhœa.

2. *Air rendered impure by the Products of Combustion.*—Bituminous coal when burnt in an open fireplace gives off three times its weight of carbonic acid gas, one per cent of its weight in fine carbon and tarry particles, and small quantities of carbonic oxide, sulphurous and sulphuric acid, bisulphide of carbon, and steam. All these products of combustion are discharged into the outer air, and, with the exception of the sooty and tarry particles, are rapidly diffused and diluted. The sulphurous acid in the air of smoky towns renders the rain acid, and proves very destructive to vegetation; and in conjunction with the sooty and tarry particles, proves very injurious and irritating to people suffering from bronchitis and asthma. During dense fogs, these injurious effects are increased, and the mortality from lung diseases always rises.

The products of combustion of coal-gas (see Appendix)

escape into the air of the room where the gas is burnt. One cubic foot of coal-gas produces, when burnt, two cubic feet of carbonic acid, together with traces of sulphurous acid. Hence if the cubic space or ventilation is deficient, the contained air becomes more speedily devitalised by the deprivation of its oxygen, while the impurities of respiration are supplemented by those of combustion. In workshops, schools, or churches, where cast-iron stoves are used, carbonic oxide may be given off, and this gas is so very poisonous that one per cent in the air may cause asphyxia. Cases of carbonic oxide poisoning have also been reported when coke is burnt in open grates. It is further worthy of note that Professor Corfield has directed attention to cases of ulcerated sore throat which he attributed to slight escapes of coal-gas from leaking pipes or burners.

3. *Air rendered impure by Household Dust and Effluvia.*—But in addition to the impurities of respiration and combustion, the air of inhabited rooms is often still further vitiated by household dust or effluvia, depending in great measure upon neglect of cleanliness. In towns this strictly domestic dust is largely increased by the minute particles which find an entrance through doors and windows; and though this cannot be avoided, much may be done to get rid of it and prevent its undue accumulation by thorough and systematic house cleansing.

Then, too, it is well known that cases of arsenical poisoning may arise from the diffusion of particles of arsenic or arseniuretted hydrogen from newly painted surfaces, or from wall-papers which contain arsenic. As a rule the symptoms are not severe, and do not go beyond conjunctivitis, irritation of the throat, nausea, and diarrhœa; but the induced debility may continue a long time before the cause is suspected. In papering a room it is important to make sure that all the old paper is peeled off and the plaster well washed, and it is also important that the paste or size used should be perfectly fresh.

4. *Air rendered impure by Sewage and Cess-pool Effluvia.*—As Pettenkofer has pointed out, there is a marked dis-

tinction between sewer air and sewer gas. The former, as in properly constructed sewers which are well ventilated and kept well flushed, is generally free from smell and innocuous, while sewage gas, whether evolved in stagnant sewers, cess-pools, or privy-vaults, is often foul in the extreme and more or less injurious to health. Amongst the gases generated by the decomposition of sewage may be enumerated carbonic acid, nitrogen, sulphuretted hydrogen, and ammonium sulphide. As the two last exist only in very small quantities, the peculiarly fœtid smell of sewage gas is due to the presence of organic matter. In the investigations on sewer air carried out by Carnelly and Haldane some few years ago, they found that the carbonic acid amounted to about twice, and the organic matter to about three times, the proportions found in the outside air at the same time. They also ascertained that under ordinary conditions sewer air is remarkably free from micro-organisms which are capable of cultivation on nutrient media; and the explanation appears to be, that, as the internal surfaces of pipe-drains and sewers are generally more or less moist, they cling to the surfaces and are not suspended in the sewer air. Indeed, those which were detected were identical with, and proportional to, those found in the outside air. Those investigations have been recently confirmed by the experiments of Parry-Laws and Andrewes, carried out under the instructions of the London County Council, who maintain that, in the absence of splashing, there is very little ground for supposing that the micro-organisms of sewage become disseminated in the sewer air. In old and defective sewers, however, and even in fairly good ones when the weather is warm and dry, putrefactive bacteria undergo enormous multiplication, fermentative changes are induced, and gases are formed which bubble up and break on the surface. In large towns and in narrow streets, where there are sewer ventilators, the odours of sewer air are at times very offensive and overpowering; and the foul effluvia given off by cess-pools, liquid privy cess-pits, soak-pits, and the like, are often even more abominable.

While numerous instances are recorded of the injurious effects of the air of sewers, cess-pits, drains, etc., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Without entering at present into the discussion as to whether this fever is solely specific, or may be generated *de novo*, there can be no question that the polluted air from cess-pits, drains, and sewers, becomes the medium through which the disease is frequently propagated, if not engendered. The sewer air, laden with pathogenic organisms, readily finds its way into houses, more especially in cold weather, on account of its greater tension, and in consequence of badly trapped or imperfectly ventilated drains. Owing, however, to the better ventilation of sewers and house-drains, the outbreaks of enteric fever traceable to sewer air, which were so common years ago, have now become comparatively rare.

Two other points connected with the propagation of enteric fever deserve notice:—(1) it seems to be clearly established that the disease may be contracted by inhaling the effluvia from enteric stools previous to their being disposed of; and (2), that if these stools be thrown into a common privy, the disease is almost certain to be conveyed to others who frequent the privy; hence the necessity of disinfecting all discharges from the patient so soon as they are passed, and of burying them wherever possible, or failing that, having recourse to systematic scavenging in the absence of water-closets and a proper system of drainage. The recent outbreak of enteric fever in the town of Hucknall Torkhard in Nottinghamshire, which was investigated by Dr. Buchanan (see Report to Local Government Board, 1897), illustrates how insanitary conditions and neglect to disinfect and properly dispose of the excreta may spread the disease by polluting the subsoil, drains, and privies, and thus specifically polluting the air. The disease in this instance was not water-borne, because the water-supply was public and constant, and there was no evidence to show that it had become con-

taminated. Nor was there any evidence to show a milk origin. But briefly the contributing agencies were these:—drainage more or less defective throughout; home treatment of all the cases under conditions of undue overcrowding, and frequently of dirt; the using of the same food utensils; the throwing of excreta, without previous disinfection, into gullies in unpaved yards and into uncovered midden-privies and ash-pits; and the soaking of the contents of these receptacles into the soil.

Amongst other serious consequences of fæcal emanations, the occasional spread of cholera and the occurrence of autumnal diarrhœa are specially to be noted. The outbreak of cholera in the City of London Workhouse, in July 1866, was believed by Radcliffe (*Ninth Report of Medical Officer of the Privy Council*) to have taken place, in all probability, in consequence of a sudden efflux of sewer air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particularly in badly-sewered districts. In Leicester, which some years ago was notorious for its excessive mortality rate from summer diarrhœa, the late Dr. Tomkins, Medical Officer of Health, observed that soon after the temperature of the ground at a depth of one foot had reached 59° to 62° Fahr., the causes producing the disease began to operate, and were confined to the low-lying parts of the borough, where the sewers were foul and retained much deposit, and the sewage percolated into the surrounding soil. This polluted condition of the soil at this temperature appeared to be highly favourable to the development of bacteria, and as the temperature fell the disease began to disappear. Dr. Tomkins also ascertained experimentally that in those districts of the borough where summer diarrhœa was most prevalent, the air teemed most abundantly with microbes or their spores; and that these spores, when cultivated, possessed the property of inducing diarrhœa in the human subject (see Chap. XV.) In rural districts, summer diarrhœa is largely associated with foul privy cess-pits or deep-midden ash-pits, and there are good

grounds for believing that many sporadic cases of enteric fever are traceable to the foul effluvia given off by the putrefactive changes which are set up, and which appear to become increasingly virulent, and contract more infective properties as scavenging is neglected, especially during warm weather.

Cases of diphtheria, ulcerated throat, membranous croup, puerperal fever, pyæmia, septicæmia, hospital gangrene, and other ill-defined ailments, have all been found to be associated with drainage defects; but why sewer gas or cess-pool effluvia should be the apparent cause of so many dissimilar diseases has not been fully explained; very probably the micro-organisms are pyæmic and not specifically pathogenic, and the disease manifestations are induced according to the part of the mucous membrane attacked, or the wound or abrasion which may become infected.

The foul emanations from streams highly polluted with sewage are undoubtedly injurious to the health of the inhabitants living on their banks. Many of them become anæmic, some suffer from sore throat, and almost all of them feel out of sorts when the nuisance becomes intensified during warm weather. In other instances, however, no such effects have been traced.

5. *Air rendered impure by Effluvia from decomposing Animal Matter.*—As regards the effects of effluvia from decomposing animal matter, such as the effluvia from decomposing carcases, the air of graveyards, the effluvia from manure-heaps, etc., on almost all these points the evidence is very conflicting. The preponderance of opinion, however, leaves no room for doubt that the effects of all such effluvia upon the health of the general population, when exposed to their influence, are more or less injurious; and in support of this view the following amongst many other confirmatory instances may be quoted:—

(1) The effluvia arising from the putrid remains of horses killed on the field of battle have frequently given rise to outbreaks of diarrhœa and dysentery amongst the soldiers. In the French camp, before Sebastopol, when

numbers of the bodies of horses lay putrefying and unburied, the effects were so serious that the spread of typhus was supposed to be due to this cause (*Parkes*).

(2) According to the evidence summed up in the Report on Extramural Sepulture in 1850, the vapours given off from thickly crowded graveyards, if not actually productive of disease, do certainly increase the sick- and death-rate of the immediate neighbourhood. Houses built on parts of disused burial sites, or in close proximity to them, would be rendered unhealthy by the entrance of impure ground air.

(3) Frequent limited outbreaks of disease have been traced to the pan-manure mixed with ashes which is conveyed in canal-boats from large towns and deposited in heaps at wharves or other landing-places in neighbouring rural districts. Such heaps, if allowed to remain in close proximity to houses, are not only extremely offensive, but may give rise to diarrhœa, ill-defined typhoid symptoms, or ulcerated sore-throat of a diphtheritic character, and the risks are intensified if children are allowed to play on or near the heaps.

6. *The Air of Marshes.*—This generally contains an excess of carbonic acid, light carburetted hydrogen, watery vapour, sulphuretted hydrogen, and organic effluvia. It also abounds with the *débris* of vegetable matter, infusoriæ, and, according to some bacteriologists, bacilli malariæ.

The more serious and characteristic effects of marsh miasmata are intermittent and remittent fevers. Ailments, however, of a less severe nature—such as diarrhœa, dysentery, and various other gastric derangements—have been attributed to their influence; and even when no marked signs of disease can be detected, the inhabitants of such districts often present an enfeebled and pallid appearance. The submerging of meadows, draining of lakes, and digging of canals, have all of them been followed by the development of marsh-diseases, probably on account of the decomposition of vegetable matter which ensues. For the same reason, a long continuance of dry

weather, followed by rains, favours the evolution of miasmata. Fortunately, in this country, marsh-diseases have become comparatively rare, though there is no doubt that in low-lying and badly-drained districts the excessive sick-rate which often prevails is in a great measure owing to atmospheric impurities of a marshy nature.

7. *Air rendered impure by Industrial Occupations or Trade-Processes.*—These may either be injurious to the workers, or, in so far as they create nuisance by the evolution of gases or effluvia, they may affect the health of the neighbourhood. It will be convenient, therefore, to summarise this part of the subject under the headings of unhealthy occupations and trade-nuisances.

(1) *Unhealthy Occupations.*—The great majority of industrial occupations are injurious or otherwise according to the quantity and nature of the dust which is produced. If the particles are soft and rounded as in coal-dust, they are not by any means nearly so injurious to the lung-tissue when inhaled as when they are sharp and angular. According to Dr. Ogle, it is mainly on account of the difference in the character of the dust particles that the workers in coal-mines are far less liable to lung affections than the Cornish miners. Like the coal-miners, the latter work under conditions of air, vitiated by respiration, combustion of lights, and gunpowder blasting, but they inhale a sharp, angular, and irritant stone-dust particle which becomes impacted in the air-cells of the lungs, and sets up chronic inflammation in the surrounding tissues. Masons, builders, bricklayers, and quarrymen also suffer to a considerable extent from the inhalation of stone-dust; but as these occupations are carried on in the open air, the effects are not so pronounced.

In coal-mining, the injurious gases given off in gunpowder blasting need no longer be a source of danger to the miner since the introduction of quicklime cartridges, which swell up when water is poured over them and exert their force without evolving any deleterious gases. Dynamite, too, is now largely used instead of gunpowder on

account of its greater explosive force, and it is preferable on health grounds because the gases evolved contain no carbonic oxide, which constitutes $7\frac{1}{2}$ per cent of the gases given off in gunpowder blasting. Roburite, another explosive which has been on trial for some time, is a compound of ammonium nitrate and nitro-benzenes. It possesses the advantage of producing no flame on explosion, but cases of poisoning have cropped up from the careless handling of the cartridges, due to the absorption of nitro-benzol through the skin, and the fumes are not without risk, as they contain a certain amount of carbonic oxide.

In all mines the evolution of carbonic gas in considerable quantities becomes a source of danger, while light-carburetted hydrogen or *fire-damp* ($C H_4$), though perhaps not markedly injurious when breathed in small amounts, must be detrimental when constantly inhaled, apart altogether from risks of explosion.

In the pottery trade, the flat-pressers and scourers at one time suffered to such an extent from the effects of the fine dust inhaled that, according to Dr. Greenhow, almost all of them became eventually asthmatical. Dr. Arlidge, however, in his Milroy Lectures, has pointed out that, owing to improved ventilation, the mortality from lung diseases has been greatly reduced among this class of workers, though it is still nearly as high as that of the tin-miners. Those of them who are employed in glazing and colouring also suffer from plumbism, and all of them are exposed to the injurious effects of great vicissitudes of temperature.

But of all unhealthy occupations, that of steel-grinding was at one time the most unhealthy. Steel-grinding is divided into dry, wet, and mixed—the most injurious effects attaching to dry grinding. Fans, however, are now commonly used to secure better ventilation, and wet grinding has become much more general, and as a result of these and other precautionary measures, the average longevity of Sheffield grinders has increased, though phthisis and lung diseases are still very prevalent amongst them.

Cutlers, file-makers, needle, pin, and tool-makers, and

workers in cycle factories, who are exposed to metallic dust, also suffer largely from phthisis, pneumonia, and bronchitis. Workers in lead, such as plumbers, painters, and glaziers, in addition to the injurious effects of dust inhalation, are liable to suffer from symptoms of lead-poisoning. File-makers, too, suffer in this respect from their using a cushion of lead on which to strike their file; while plumbers inhale volatilised oxide of lead and painters the dust of white lead. Lead is also taken into the system by workers in lead when meals are eaten with unwashed hands. There is generally a blue line to be detected on the edge of the gums due to sulphide of lead. Formerly lucifer-match makers suffered frequently from necrosis of the lower jaw caused by phosphorous fumes, but this disease is now averted to a large extent by the use of red amorphous phosphorus.

Brassfounders suffer from "brassfounder's ague," which is characterised by shiverings, tightness of the chest, headache, nausea, muscular pains, and feverishness. By some it is supposed that the disease is due to the ingestion of metal dust, and is a form of copper- and zinc-poisoning, as copper-smiths are liable to be attacked by similar symptoms. The men who suffer most are those who are new to the work, and they lessen the severity of the attack by drinking large quantities of milk. A green line is sometimes to be detected on the lower jaw.

Before electro-plating replaced the old methods, silverers and gilders, who worked with amalgams of gold and silver with mercury, were very liable to mercurialism; while workers in the manufacture of wall-papers and artificial flowers are apt to suffer from symptoms of arsenical poisoning.

Pearl-button makers, and workers in flax or shoddy mills, are liable to be afflicted more or less with bronchial irritation, and many of them with decided lung disease. Cotton-weavers also suffer very much from the fine dust given off by the "sizing"; and several years ago an inquiry was made by Buchanan at Todmorden, which revealed the

great prevalency of lung disease, dyspepsia, and permanent epistaxis, amongst this class of operatives. The damp and heated atmosphere in which this class of operatives work has also a very injurious effect upon health.

Amongst wool-sorters the disease known as anthrax has at times proved very fatal, the poison being conveyed into the system generally by inhalation of the fine dust given off in cleaning the wool, though it also may be conveyed by local inoculation. Several outbreaks have been investigated —notably one by Dr. Russell, Medical Officer of Health for Glasgow; and another, which occurred at Bradford, by the late Dr. Spear, Local Government Inspector. (See *Supplements to Local Government Reports* for 1878 and 1880, and *Departmental Report to Home Office*, 1897.)

It is here worthy of special note that Dr. Arlidge in his "Milroy Lectures," delivered before the College of Physicians in 1889, on "Occupations and Trade in relation to Public Health," has divided the conditions causative of disease as follows:—

Generation of dust { Poisonous. / Non-poisonous. / With heat and moisture.
Employment of materials of a distinctly poisonous nature.
Evolution of poisonous or injurious vapour.
Excessive temperature.
Evolution of electricity.
Abnormal atmospheric pressure.
Circumstances affecting special senses.
Excessive use, friction, or strain in parts of the body.
Exposure to infectious, contagious, or parasitic diseases.
Extra liability to accidents.

(2) *Trade - Nuisances.* — These embrace the noxious gases or vapours given off in certain trades in which mineral substances are principally dealt with, such as alkali-works, chemical works, brickfields, gasworks, etc., and what may be strictly called effluvium trade-nuisances, of animal or vegetable origin.

The principal gas evolved in alkali-works is hydrochloric acid. Its effects on vegetation are very destructive,

but with proper care in the condensation of the gas, there does not appear to be any evidence to show that works of this description are injurious to the health of those living in the neighbourhood.

From chemical works, and especially from those in which gas liquor is utilised for the production of salts of ammonia and other chemical compounds, the injurious gases evolved consist chiefly of sulphuretted hydrogen, ammonium sulphide, and traces of other ammonium compounds. The workmen employed at such works apparently enjoy good health, but when the noxious vapours are not properly consumed by being collected and passed through a furnace, there is no doubt that they do affect the health of the neighbouring inhabitants, though not to any serious extent.

In bleaching works, large quantities of sulphur dioxide are evolved, and the bleachers often suffer from bronchitis and anæmia; while in galvanised rubber works, the men employed are liable to suffer from severe nervous depression, sleeplessness, and loss of appetite, due, it is believed, to the inhalation of carbon disulphide fumes.

The peculiarly pungent odour of brickfields can be felt at several hundred yards' distance; but though several cases are recorded in which the existence of a nuisance was fully established, none are quoted as having proved that the health of the neighbourhood was affected.

Gasworks are often productive of great nuisance, and probable injury to the health of persons living in the immediate neighbourhood, by the accumulation of lime used for purification, and through want of proper precautions in removing waste ammonial products. The manufacture and use of water-gas is not without its dangers, as it contains as much as 30 to 40 per cent of carbon monoxide (CO), and many cases of water-gas poisoning have recently been reported in America, and some few in this country, due to carbon monoxide asphyxia.

With respect to the effects of trade-nuisances on the general health of the community, an important inquiry was conducted some few years ago by the late Dr. Ballard in be-

half of the Local Government Board, which is of special interest to sanitary authorities and their officers throughout the country. The trades embraced in the inquiry included—(1) the keeping of animals; (2) the slaughtering of animals; (3) branches of industry in which animal substances are principally dealt with; (4) trades in which vegetable matters are principally dealt with; (5) trades in which mineral substances are principally dealt with; and (6) trades in which matters of mixed origin are dealt with. According to Dr. Ballard, the most offensive effluvia are those given off from trade-processes, in which the materials used consist of animal substances—such as gut scraping, manure manufacturing, and the melting of some kinds of fat. The industries which deal with vegetable substances, though often very offensive, do not appear to give rise to effluvia which may be designated disgusting, and are therefore not so liable to be injurious; while those which treat mineral substances are chiefly offensive owing to the irritant gases and other effluvia which are given off. As might be expected, great difficulty was experienced in ascertaining, with any approach to precision, in what respect, and to what extent, these effluvia are injurious to health; but as regards all of them, it has to be noted that in records of proceedings of Courts of Law, and as the result of Dr. Ballard's inquiries, the particular group of symptoms generally complained of consisted of "loss of appetite, nausea, sometimes actual vomiting, sometimes diarrhœa, headache, giddiness, faintness, and a general sense of depression and *malaise*." Concerning effects of a more definite nature, it was also made clear that while trade effluvia generally contribute their quota of conditions which render the air of manufacturing towns comparatively insalubrious, there are certain effluvia of septic origin connected with businesses of a specially filthy nature, which are undoubtedly unwholesome, and give rise to filth diseases of various kinds. Other trades, again, in which matters are dealt with which are liable to be infected with specific contagia, cannot fail to be dangerous to persons

exposed to such influence; while, as regards trades which give off effluvia consisting of definite chemical compounds, they are, as a rule, only irritating or injurious in proportion to their degree of concentration. (See *Supplements to Reports of Medical Officer of Local Government Board*, 1876-77-78, and Chapter XIX.)

CHAPTER IV

VENTILATION AND WARMING

These two subjects may be conveniently treated under the following sections :—

I. The Amount of Fresh Air required.
II. The Necessary Amount of Cubic Space.
III. Natural Ventilation.
IV. Artificial Ventilation, Warming, and Lighting.

Section I.—The Amount of Fresh Air required

As the air contained in an inhabited room cannot, under the most favourable circumstances, be maintained in as pure a condition as the external air, the object of ventilation is to reduce the impurities of respiration to such an extent that continued inhalation of them will not be detrimental to health. While this can only be effected by a constant supply of fresh air, it is evident that the quantity required will very much depend on the amount of impurities which may be allowed to accumulate in respired air without proving injurious. The first point, therefore, which has to be determined is the limit of maximum impurity consistent with the maintenance of perfect health. It has already been shown that the amount of carbonic acid in air vitiated by respiration is a tolerably reliable index to the other impurities; and hence the question resolves itself into this,—What amount of CO_2 shall be accepted as the standard of permissible

maximum impurity? After numerous experiments, and a most extended inquiry, the late Dr. Parkes gave it as his opinion that, allowing 0·4 volume as the average amount of CO_2 in 1000 volumes of air, this standard ought not to exceed 0·6 per 1000 volumes, because, when this ratio is exceeded, the organic impurities, as a rule, become perceptible to the senses. With a ratio of 0·8, 0·9, or 1 per 1000 volumes, the air smells stuffy and close, and beyond this it becomes foul and offensive.

The desirability of adopting Parkes's estimate as the standard of maximum impurity is also borne out by the observations and experiments of Pettenkofer, Angus Smith, and De Chaumont. "We all avoid," wrote Dr. Angus Smith, "an atmosphere containing 0·1 per cent of carbonic acid in crowded rooms; and the experience of civilised men is, that it is not only odious but unwholesome. When people speak of good ventilation, they mean, without knowing it, air with less than 0·07 per cent of carbonic acid. We must not conclude that because the quantity of carbonic acid is small, the effect is small; the conclusion is rather that minute changes in the amount of this gas are indications of occurrences of the highest importance."—(*Air and Rain.*)

Assuming, then, that 0·6 CO_2 per 1000 volumes is accepted as the standard of maximum impurity, and remembering that an adult at rest exhales on the average 0·6 cubic feet of CO_2 per hour, the next question comes to be —How much fresh air must be supplied per head per hour, in order that the respired air should not contain impurities in excess of this standard? Taking the initial CO_2 contained in the atmosphere at the normal ratio of 0·4 per 1000 volumes, the permissible limit of respiratory impurity is thus seen to be 0·2 CO_2 per 1000 cubic feet, or 0·0002 per cubic foot. With these data it is evident that it will require 3000 cubic feet of fresh air per head per hour to prevent the contained air in a room from exceeding 0·6 CO_2 per 1000, because $0{\cdot}0002 \times 3000 = 0{\cdot}6$, the amount of CO_2 exhaled by each individual per hour. This is expressed

in the following equation, in which c represents the amount of CO_2 exhaled, r the respiratory impurity per cubic foot of air, and d the delivery of fresh air required, or amount available, thus :—

$$\frac{c}{r} = d, \text{ then } d = \frac{0{\cdot}6}{0{\cdot}0002} = 3000\ ;$$

or, $\frac{0{\cdot}6}{0{\cdot}2} = 3 =$ number of *thousands* of cubic feet of air required per head per hour. In any given problem, if c and r are known we can find d, and if d and c are known we can find r. Thus, we will suppose that the limit of total impurity is fixed at 0·7 CO_2 per 1000 volumes, then $\frac{0{\cdot}6}{0{\cdot}7 - 0{\cdot}4} \times 1000 = 2000$ cubic feet, the amount of fresh air which would be required per head per hour. Or, to take the following examples :—

1. Suppose a room of 2000 cubic feet capacity is occupied by six persons for four hours, what will be the total amount of CO_2 per 1000 volumes at the end of the time, assuming that 12,000 cubic feet of air per hour have been supplied? (*Cambridge University Exam.*)

In this problem d, the total amount of air available for breathing by the six persons in the four hours, is 2000 cubic feet (the cubic space of the room) + 12,000 cubic feet × 4 (the amount of air supplied in four hours) = 50,000 cubic feet; while $c = 0{\cdot}6 \times 6 \times 4 = 14{\cdot}4$ cubic feet, the total amount of CO_2 expired. It is now required to find r.

$$d = \frac{c}{r} \text{ or } r = \frac{c}{d} = \frac{14{\cdot}4}{50{,}000} = 0{\cdot}000288,$$

or the respiratory impurity is 0·288 parts per 1000, and the total impurity will be $0{\cdot}288 + 0{\cdot}4 = 0{\cdot}688$ CO_2 per 1000 volumes.

2. How much fresh air per hour is required for a hall containing 300 persons in order that the air in the hall may not yield more than 0·8 CO_2 of total impurity per 1000 volumes?

Here $r = 0{\cdot}8 - 0{\cdot}4 = 0{\cdot}4$,
and $c = 0{\cdot}6 \times 300 = 180$,

then $d = \frac{180}{0{\cdot}4} \times 1000 = 450{,}000$ cubic feet, or 1500 cubic feet per head.

If the cubic contents of the occupied space are given, the amount of CO_2 in the contained air must be taken into account, and this will lessen the amount of fresh air required at the close of the first hour. Thus, in the above

example, we will suppose that the size of the hall is 200,000 cubic feet, then the amount actually required during the first hour would be $450{,}000 - 200{,}000 = 250{,}000$ or 833·3 cubic feet per head. After the first hour, to maintain the CO_2 at 0·8 the total amount of 450,000 cubic feet of fresh air would be required. In all these calculations it is assumed that an equal volume of impure air is removed to make room for the entrance of the fresh air.

The results obtained by actual experiment accord so closely with those which have been deduced from calculation that some of them may be fitly quoted here. The following were given by De Chaumont as selections from a series of observations made at Aldershot Camp:—In a room containing 18 men, with a supply of 1200 cubic feet of fresh air per head per hour, the CO_2 was found to be ·855 per 1000 volumes; in another containing 13 men, with a supply of about 1700 cubic feet, it was ·759 per 1000 volumes; and in a third, containing 22 men, and with a supply of about 765 cubic feet per head per hour, it amounted to 1·2 per 1000 volumes. All these observations were made at the same hour (5 A.M.), and in barrack-rooms ventilated on the plan proposed by the Barrack Commissioners in 1861, which provided that at least 1200 cubic feet of fresh air should be delivered per head per hour.

But there are other circumstances in which it is necessary to augment the delivery of fresh air in order to maintain the standard of purity. When lights are used, for example, and the products of combustion are allowed to pass into a room, a large supply is required to keep the contained air sufficiently diluted. Thus it is found that 1 cubic foot of coal-gas destroys the oxygen of 8 cubic feet of air in combustion, and produces about 2 cubic feet of CO_2, besides other impurities. As a common gas-burner burns about 3 cubic feet of gas per hour, the CO_2 produced amounts to about 6 cubic feet, or ten times the amount exhaled by an adult at rest. Then, again, it should be noted that, inasmuch as a man exhales more CO_2 and other respiratory impurities during work than when at rest, the amount of

fresh air per head per hour supplied to workshops and factories should be considerably in excess. Assuming that at light work an adult exhales 0·95 cubic feet CO_2 per hour, and at hard work 1·96, then the fresh air delivery for the former should be 4750 cubic feet per hour, and for the latter 9800 cubic feet.

It is evident also that the sick require a larger supply of fresh air than the healthy, for it has been found that when as much as 3500 to 3700 cubic feet have been delivered per patient per hour, hospital wards have not been free from offensive smell, owing to the greater amount of organic impurities given off.

Carnelly, Haldane, and Anderson, adopting a threefold standard impurity of carbonic acid, organic matter, and microbes, proposed that instead of 0·6 carbonic acid per 1000, the permissible limit should be 1·0 for houses and 1·3 for schools.

Section II.—Cubic Space

This should be large enough to permit the passage of 3000 cubic feet of air per head per hour, without producing perceptible draughts. If the cubic space per head is small, the renewal of air will necessarily be much more frequent than when it is large. Thus, with a space of 100 cubic feet, the contained air must be renewed thirty times per hour, in order that the standard amount be supplied; whereas, with one of 1000 cubic feet, only three renewals of air would be required. What, then, is the minimum amount of cubic space through which the standard amount of fresh air can be passed without perceptible movement? Professor Pettenkofer has answered this question experimentally, and has found that by means of artificial ventilation, and with the aid of the best mechanical contrivances, the air in a chamber of 424 cubic feet can be renewed six times per hour without creating any appreciable air-currents. No doubt, therefore, such a space as this, or one somewhat smaller, can be efficiently ventilated, provided that perfect artificial means be employed, and the air warmed;

but with natural ventilation this becomes impossible. Indeed, a change of air three or four times per hour is all that can be borne in this country without discomfort, and this would require an initial air-space of 750 to 1000 cubic feet. Practically speaking, the difficulties of ventilating small spaces efficiently are due not so much to the movement of the contained air as to the relative position of the inlets, these being of necessity so near the person that the draughts which are produced become disagreeable or injurious. This is well exemplified in the case of prisons. In hard-labour prisons, where convicts are confined in their cells only during the hours of rest, the cell-space seldom exceeds 200 cubic feet. The consequence is that in cold or inclement weather these draughts become so unpleasant that many of the prisoners block up the inlets as effectually as they can, and of course obstruct the ventilation to a serious extent. So far as my experience goes, it is difficult, even with the aid of a well-devised plan of ventilation, to supply the necessary amount of fresh air per head per hour without creating perceptible draughts occasionally, if the space be less than 600 cubic feet. I have further satisfied myself that with the same artificial appliances and arrangements, the air contained in small occupied spaces becomes much more impure than in large spaces. For example, in a series of experiments which I had a share in conducting a good many years ago, the cell-space in one-half of a convict prison was 210 cubic feet, in the other half it was 614. The same means for extracting the foul air through flues leading from every cell to a foul-air extraction shaft, in which a furnace was kept burning to produce a constant draught, were common to both parts of the building. Moreover, the fresh-air inlets were more amply provided for in the small than in the large cells, and yet the average amount of carbonic acid, after a series of observations, was found to be 1·044 per 1000 volumes in the former, and only ·720 in the latter.

These results accord very closely with those which have been recently obtained by Carnelly, Haldane, and Anderson,

as will be seen from the following table, which gives in addition to the CO_2 the relative amount of organic matter and number of microbes per litre :—

AVERAGE RESULTS OF ANALYSES OF AIR IN SLEEPING ROOMS BETWEEN 12.30 AND 4.30 A.M. (*Carnelly, Haldane, and Anderson*).

Cubic Feet per Head.	Temperature (Fahrenheit).	Carbonic Acid per 1000 vols.	Organic Matter (vols. of Oxygen required per million vols. of air).	Microbes per litre.
100–180 . .	55°	1·15	15·1	80
180–260 . .	54°	1·07	15·1	49
260–340 . .	53°	1·03	11·8	32
340–500 . .	57°	0·92	8·4	42
500–1000 . .	54°	0·86	5·6	6
1000–2500 . .	53°	0·67	3·9	9

With a small cubic space it is impossible to obtain uniform diffusion of the contained air, if a large amount of fresh air is supplied, because between inlet and outlet a direct current is established, and a considerable quantity of air passes right through without being utilised. Again, it is evident that if the ventilation is impeded or becomes arrested, impurities will collect with far greater rapidity in a small than in a large space, and this of itself is a great argument in favour of the adoption of an ample cubic space as a basis.

With ordinary means of ventilation (artificial excluded), both Parkes and De Chaumont contended that the cubic space for a healthy adult ought at least to be 1000 feet. It is true this is very much in excess of what is generally obtained. In the crowded dwellings of the poorer classes it seldom reaches 200 to 250 cubic feet; but then the disastrous effects declare themselves but too clearly in the increased rate of mortality. In metropolitan lodging-houses the allowance per head is as low as 240 cubic feet; in the

Dublin registered lodging-houses it is 300; in workhouse dormitories it is 300; while in Board Schools the Education Department require only 100 cubic feet as a minimum. The Barrack Commissioners, on the other hand, recommended a minimum space of 600 cubic feet for soldiers, insisting at the same time that the air should be renewed at least twice every hour.

For further remarks on cubic space in hospitals, see Chapter on Hospitals.

In summing up this part of the subject, the following may be accepted as the standard conditions necessary for the requirements of *perfect* health:—

1. That the limit of maximum impurity of air vitiated by respiration ought not to exceed 0·6 carbonic acid per 1000 volumes.

2. That to ensure the maintenance of this standard under ordinary circumstances, 3000 square feet of pure air must be supplied per head per hour.

3. That for this purpose, and with ordinary means of ventilation, a space of at least 1000 cubic feet should be allowed per head in buildings permanently occupied.

It may be objected that these conditions aim at too high a standard, and that in general they are seldom met with; but it must be remembered that they are based on a firm foundation of facts, and that, though it may not be possible to prove in all cases that bad effects result from a neglect of them, it does not follow that such bad effects may not have been produced. In a country like this, with a climate so variable, the cubic space allowance is a most important element in any scheme of ventilation. It should be ample enough to permit of a sufficient supply of fresh air without creating injurious draughts, and yet not too large to interfere with the maintenance of a sufficient and equable temperature during cold weather. Where artificial ventilation is provided, and when the fresh air can be heated before entering, it may be as low as 400 cubic feet, but even then the ventilating arrangements must be much more perfect than they usually are. In the case of healthy adults, such

as soldiers and prisoners, the standard allowance may also be considerably lessened, if care be taken that the free entrance of fresh air at all hours and in sufficient quantity shall not be interfered with. Unfortunately the question of cubic space is a question of large outlay, and hence the desire to economise tends to curtail the minimum not within safe limits, but within limits that will not be attended with glaring injurious effects.

Then, too, it should be noted that an essential item in cubic space is the superficial area, or floor space, which is necessary for each individual. If the height of the room is over 12 or 14 feet, excess in this direction does not compensate for diminished floor space, because it is found that the organic impurities of respiration tend to accumulate in the lower strata of the contained air. In metropolitan lodging-houses the superficial space allowed for each individual is 30 feet, and in hospitals the minimum is about 90, while in Board Schools it is fixed at the exceedingly low floor space of 10 square feet in London, and 8 square feet in the provinces. Generally speaking, the minimum floor space should not be less than one-twelfth of the cubic space.

For horses 1200 to 1800 cubic feet, with 100 to 120 square feet of floor space, should be allowed; and Ballard has recommended that dairy cattle should have at least 1000 cubic feet per cow. Very often, however, the cubic space does not exceed half this amount.

Section III.—Natural Ventilation

Natural ventilation is carried on by the agency of natural forces, such as gaseous diffusion, and movements of air produced by inequalities of temperature.

1. *Diffusion.*—The force of gaseous diffusion, upon which the uniform constitution of the atmosphere itself depends, is manifestly inadequate as a ventilating power. It operates chiefly in producing, as has been already stated, a tolerably

equal distribution of the gaseous products of respiration and combustion throughout the air contained in a room, but aids only to a very slight extent the removal of these impurities from the room, while it is altogether inoperative as regards the removal of organic impurities.

2. *Movements of Air produced by Inequalities of Temperature.*—As common air is subject, like other gases, to the laws of gaseous expansion, it undergoes a certain increase or diminution in bulk, according as it is heated or cooled. Warm air is therefore lighter than cold air, and hence a constant interchange goes on through every available opening, whenever there is any difference between the outside and inside temperature. The contained air on being heated expands, a portion of it escapes, and the colder outside air rushes in to establish the equilibrium. Indeed, the movements produced by inequality in weight of masses of air at different temperatures are the natural means by which ordinary ventilation of houses is chiefly carried on in this climate, and especially during the colder months of the year. The law which governs these movements will, however, be more fitly explained later on.

But in addition to the slighter currents, the movements of the external air, or winds, greatly assist ventilation by their perflating or aspirating action. Perflation is best exemplified in the cross-ventilation which takes place through opposite windows when opened. This is by far the readiest means which can be adopted for removing speedily and effectually aerial impurities from a room, but it cannot always be depended on, on account of the uncertainty of the rate of movement; for if the air be stagnant, there can be little or no perflation, while, on the other hand, if the rapidity of movement is great, perflation becomes insupportable in consequence of the draughts produced. A current of cold air moving at the rate of five or six feet per second becomes unbearable. In spite of this objection, however, cross-ventilation should always be provided for whenever it is practicable, and especially in large rooms, such as hospital wards.

The aspirating action of the wind produces up-currents through chimneys and air-shafts, by creating a partial vacuum in them, which is constantly being filled by the column of air from beneath. The mechanical arrangements which have been proposed or adopted to facilitate the action of these natural ventilating powers are so numerous and varied, that only a brief mention of the more important of them can be given. To utilise the perflating force of the wind, opposite windows should be made to open from the top and bottom, and to obviate the unpleasantness arising from draughts, some such arrangements as the following have been recommended:—

(1) By having the window so constructed that the top slopes inward when it is opened, so that the entering current of air impinges against the ceiling. If the window is large, as in churches, schools, or hospitals, only a section of the upper part may be made to open in this way.

(2) By substituting a glass louvre for the top centre pane.

(3) By having some of the panes doubled; the outer with an open space at the lower edges; the inner with an open space of the same size at their upper edges. The air on entering is thus made to pass upward between the panes.

(4) By having some of the panes made of perforated glass, as in Pott's plan.

(5) By raising the lower sash of the window two or three inches and filling in the opening under the bottom rail with a suitable piece of wood. This leaves a corresponding space between the meeting rails in the middle of the window through which the entering current of fresh air is directed towards the ceiling.

(6) By having a part of a pane to open or shut at will by a spring arrangement, as in Boyle's ventilator.

(7) By fixing a fine wire screen to the top of the window, which unfolds when the window is pulled down, and folds up when the window is shut. As the fine meshes of the screen are apt to become clogged up with dust, this

plan is objectionable, except when the windows are of low elevation, as in attic rooms.

Other outlets and inlets may be provided by inserting perforated bricks in the walls near the ceiling. One of the best inlets is the Sheringham valve, which closes at will by a balanced weight. It slopes inwards and upwards when open, so that the entering current of air, which first passes through a perforated brick or grating, is directed towards the ceiling. Ellison's conical bricks, which are pierced with conical holes, are so constructed as to admit outer air without creating perceptible draught.

In some cases cross-ventilation can be tolerably well maintained, independently of opposite windows, by means of tranverse ventilating boxes or tubes, situated at regular distances, and in close proximity to the ceiling. These boxes or tubes extend from wall to wall, and communicate with the external air at either end by air-bricks. The sides are made of perforated zinc, and there is a diaphragm in the centre of each, to prevent the wind from blowing right through. According to the direction of the wind, one-half the tube becomes an inlet for fresh air, which falls gently into the room through the perforated zinc, while the other half becomes an outlet for the vitiated air.

This plan does very well for large hospital wards having an internal corridor running along one side. Inner rooms can also be supplied with a certain amount of cross-ventilation in the same way.

What is known as Tobin's plan of ventilation consists in introducing fresh air by means of vertical tubes carried for a certain distance up the walls of the room, so as to obviate any discomfort arising from down-draught. In rooms or class-rooms with windows only on one side, this is a very convenient method of improving the ventilation. A similar method of ventilating by pipes, introduced by Shorland of Manchester, has also been found to work very well.

The aspirating power of the wind is frequently utilised by placing cowls on the tops of air-flues or chimneys. If not made to rotate according to the direction of the wind

by means of vanes, they should be so constructed as to prevent the entrance of rain. Among cowls which have received favourable notice may be mentioned the various cowls patented by Kite and Co., Banner, Boyle, Buchan, and Ellison.

According to experiments conducted some years ago by a Committee of the Sanitary Institute at Kew Gardens, the great majority of cowls tested showed no superiority in aspirating power over the simple open tube.

Louvres are sometimes used instead of cowls, but, unless specially constructed, they are apt to let in the rain and permit down-draughts.

In several plans of natural ventilation the perflating and aspirating powers of the wind are both taken advantage of. Thus, by a suitable arrangement of shafts and cowls, this mode of natural ventilation can be made to do excellent service in ships, and in buildings so constructed or situated that other ventilating means will not suffice. It was on this principle that Arnott ventilated the Field Lane Ragged School so successfully. The entrance and exit tubes were both fitted with cowls, the one set turning away from the wind, the other facing the wind. The latter also were of a higher elevation than the former, in order to increase their extractive power.

In Varley's plan, which has been found to work well in schools, a perforated zinc tube, communicating with the external air, passes along the cornice of three sides of the room, while on the fourth side another perforated tube is connected with the chimney, which acts as the extraction-shaft.

The plan proposed by M'Kinnell, though it belongs to the same category, is less widely applicable, because it is only suited for one-storied buildings or upper rooms. It consists of two hollow cylinders, one within the other, and of such relative calibre that the transverse area between the tubes is equal to the sectional area of the inner tube. The inner tube is of slightly higher elevation than the outer, and acts as the outlet. The fresh air enters between the tubes,

and is thrown up towards the ceiling by means of a horizontal flange surrounding the lower margin of the inner tube. Both tubes should be situated in the centre of the

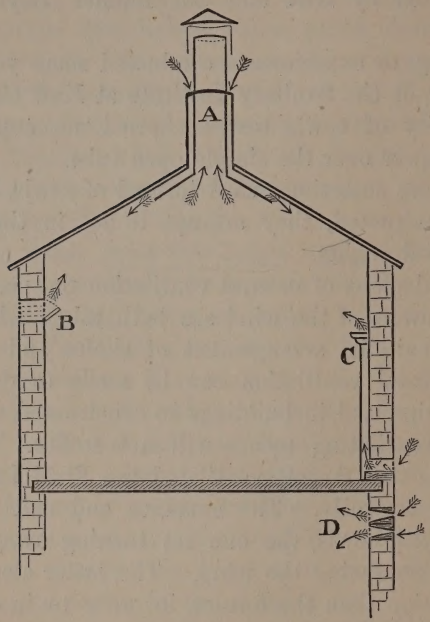


Fig. 1.—A, M'Kinnell's Ventilator; B, Sheringham Valve; C, Tobin's Tube with water tray; D, Ellison's Conical Brick Ventilators.

ceiling or roof. Some of these ventilating arrangements and appliances are illustrated in Fig. 1, though it need hardly be pointed out that they would not all be required to ventilate the same room.

Section IV

Artificial Ventilation, Warming, and Lighting

Artificial ventilation is carried on either by forcing the air into and through a room (propulsion), or by drawing the air out of a room (extraction). These two methods are also spoken of as the *plenum* and *vacuum* systems of ventilation.

Although it may appear to be an easy matter to ventilate a room without any regard to temperature, or to warm it without providing for a due supply of fresh air, it becomes a problem of very considerable difficulty to ensure, in all cases, that both the ventilation and warming shall be efficient and satisfactory. This difficulty depends in a great measure on the fact that the means employed in ventilating necessarily dissipate and carry off a certain quantity of the heat which should be utilised for warming purposes.

The heat used for warming is propagated by radiation, conduction, or convection, or a combination of two or all three of these methods. The heat emitted by an incandescent fire is chiefly radiant, though part of it is reflected from walls and articles of furniture, which in becoming warmed assist in propagating the heat by conduction. Hot-water pipes and close stoves, on the other hand, warm the air by convection, but if their surfaces are polished they also give out a considerable amount of radiant heat. Convection depends on the mobility of gases and fluids, which on being heated expand and rise, the displaced and warmed particles being continuously replaced by the colder and heavier particles. A circulation of the air or water is thus kept up and the whole mass soon becomes warmed. Conduction of heat takes place through all solids, and to a certain extent through liquids and gases, but these are in themselves very bad conductors. Metals are better conductors than stone, and some metals are far better conductors than others. Copper, for example, is more than four times as efficient as iron for transmitting heat from any source to the surrounding medium, and were it not for its higher price it would form the best material for stoves, hot-water pipes, steam pipes, or warm-air pipes. Porous and felty materials are in themselves bad conductors, and are therefore very useful when it is desired to impede the loss or escape of heat. Thus a boiler may be encased in felt, while the hot-water pipes may be of polished metal to aid the emission of heat by conduction and radiation.

Radiant heat passes through the air without warming it,

and its intensity is inversely as the square of the distance of the heated object from the source of the heat. Thus two similar objects at distances of three and four feet from an open fire-place would receive heat in the proportions respectively of 16 to 9.

In this country ventilation and warming are usually provided for by open fire-places. The heat is obtained by radiation from the incandescent fire, and by radiation and reflection from the different parts of the grate, furniture, etc., while ventilation is carried on by the constant current of heated air rushing up the chimney. Even when there is no fire, the chimney acts as a very efficient ventilating shaft.

When doors and windows are closed and a fire kept burning, the fresh air enters the room through every chink and opening, provided there are no special inlets. Hence it follows that the more closely doors and windows are made to fit, so much greater are the obstacles to the entrance of fresh air. When this is the case, the fire feeds itself by establishing a double current in the chimney, the downward current entering the room in puffs, and carrying with it clouds of smoke. Generally, however, doors and windows are not made to fit so closely that a sufficient amount of air for feeding the fire cannot enter, and under ordinary circumstances the supply and circulation are somewhat as follows: —The greater portion of the fresh air enters beneath the door, and is drawn along the floor towards the fire-place. It is warmed to a certain extent during its course by the radiating heat of the fire, and when it approaches the fire-place part of it rushes up the chimney along with the smoke, while the other part ascends towards the ceiling, and after ascending passes along the ceiling towards the opposite end of the room. During its progress it becomes cooled, and therefore descends to be again drawn towards the fire-place with a fresh supply from beneath the door and through the chinks of the window-frames, if they are not air-tight. As the air which thus enters is usually cold air, it is evident that the room is insufficiently or unequally warmed and

badly ventilated. At the end of the room opposite the fire-place the temperature is below the average, and the cold current near the floor chills the feet. Moreover, the air is not properly diffused, so that although a sufficient supply may actually be entering, impurities are apt to accumulate in the centre and upper parts of the room.

The position of the fire-place is likewise a matter of considerable importance. The practice followed by most builders is to place fire-places in external walls, by which means a large amount of heat is wasted. If, on the other hand, they are grouped in the centre of the house, more heat is utilised, and greater equability of the inside temperature is maintained.

With ordinary fire-places it is found that nearly seven-eighths of the heat generated passes up the chimney, along with a quantity of air varying from 6000 to 20,000 cubic feet per hour. While, therefore, a single chimney will on the average act as an efficient ventilating shaft for a room containing from three to six or more persons, it is quite clear that by far the greatest portion of the fuel is wasted as a warming agent. The structure of the fire-place thus becomes a matter of special importance, because not only may the fuel be economised to a considerable extent, but by certain mechanical arrangements an equable temperature may be maintained and the air warmed before it enters the room.

Of the fire-places adapted to meet these requirements, one of the best and first devised is the ventilating grate designed by Sir Douglas Galton (see Figs. 2, 3, 4, and 5). It provides for an air-chamber at the back, in which the fresh air is heated before it enters the room. If the fire-place be built in an external wall, the inlet for fresh air may be situated immediately behind, but if in an inner wall, a channel communicating with the external air by perforated bricks or gratings, and passing beneath the flooring or behind the skirting, must be laid. On the back of the stove broad iron flanges are cast, so as to present as large a heating surface as possible. These project backwards into the

chamber, and this heating surface is further supplemented by the smoke flue, also of iron, which passes through the chamber, and is made continuous with the chimney. The fresh air, heated in this manner, enters the room by a louvred opening situated between the fire-place and ceiling, or by two such openings, one at either side of the chimney-breast. The grate itself is so constructed that the greatest amount

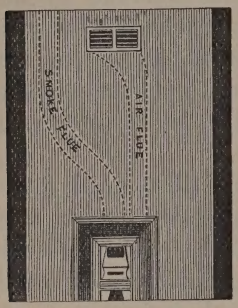


FIG. 2.—Elevation, showing air and smoke flues.

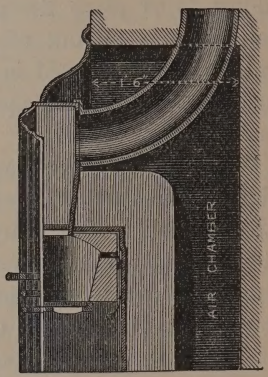


FIG. 3.—Section of grate.

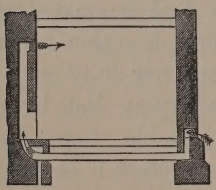


FIG. 4.—Section of a room showing air-duct and flues.

FIG. 5.—Plan of grate and air-chamber.

(After GALTON.)

of obtainable reflected heat is given off, and a more perfect combustion of the smoke effected than with an ordinary grate. The stoves are of different designs and sizes, to suit existing chimney-openings and different sized rooms. They have the same cheerful aspect as the ordinary grate, and produce the same degree of warmth in the room with a third of the quantity of fuel; besides, the temperature of the room is much more equable, and unpleasant draughts of cold air are avoided. Several varieties of ventilating grates, but all of them constructed on the same principles as the Galton

grate, have been produced from time to time, but only one or two need be mentioned. In Boyle's ventilating grate, for example, the heated air enters the room through a transverse fenestrated opening extending along the top of the grate. In Shorland's patent Manchester grate, which has been highly spoken of, the warmed outside air is made to enter the room through the shelf of the chimney-piece, and by means of special flues it can be conveyed to bedrooms above. Kitchen stoves have also been constructed on the same principle, and ventilating grates suited for the centre of halls or hospital wards. The smoke flue of the latter is made to pass out under the flooring, as well as the fresh-air entrance channel.

But in addition to their warming properties, various grates have been specially devised to economise fuel and consume their own smoke. The vast majority of grates at present in use are constructed on wrong principles by allowing the cold air to rush through the centre of the fire, thus causing rapid consumption of the fuel, and sending the warmth along with the half-burned gases up the chimney. In order to economise fuel it is necessary to cut off this stream of cold air which passes through the bottom of the grate;—an arrangement which is carried out in all grates made with solid fire-brick bottoms, after the pattern of the Parson's, Abbotsford, or Kyrle grates. But, as Mr. Pridgin Teale has so clearly pointed out in a small brochure on economy of coal, the same results can be obtained by closing up the open chamber under the grate by means of a close-fitting shield or door, which can be made by any blacksmith or ironmonger. Indeed, according to Mr. Teale's experiments, grates provided with these shields, or "economisers" as he calls them, answer better than those with solid fire-brick bottoms, and he gives some excellent rules regarding the construction or alteration of fire-places, which are of such general application that they may be fitly quoted here:—

"1. Use as much fire-brick and as little iron as possible. 2. The back and side of the fire-place should be made of fire-brick. 3. The back of the fire-place should lean or arch

over the fire. 4. The bottom of the fire or grating should be deep from before backwards (not less than 9 inches for a small room). 5. The slits in the grating should be narrow. 6. The bars in front should be narrow. 7. The chamber beneath the fire should be closed in front by a shield or "economiser." In lighting the fire it is well to draw away the economiser for a short time until the fire is well started. If an "economiser" is not used, considerable saving of fuel may be effected by having an iron plate made to fit the bottom of the grate and laid on the bars.

Great improvements, too, have recently been made in close stoves and kitcheners, both as regards economy of fuel and smoke abatement, while gas cooking stoves are coming into much more general use, especially during the summer months. There are also several very admirable gas ventilating stoves such as the well-known Calorigen stove invented by Mr. George, and Dr. Bond's Euthermic Ventilating Stove. For warming and ventilating bedrooms, the Thermic Ventilator devised by Mr. Lawson Tait of Birmingham may be mentioned as a cheap and effective arrangement.

The great objection to many of the commoner kinds of stoves depends on the fact that their over-heated surfaces dry the air to a very unwholesome extent, even when the fresh air is conveyed by a special entrance channel. Numbers of them, however, are put up without providing any such channel, so that the air not only becomes dry and burnt, but exceedingly close and unpleasant, and when cast-iron stoves are used carbonic oxide gas may be evolved. Evaporating dishes placed on the stoves will assist in keeping the air from becoming too dry, or painting the iron surface with a solution of silica, as suggested by Dr. Bond, may prevent the evolution of carbonic oxide; but it is much preferable, and in the long run more economical, to have a good ventilating stove erected in the first instance. Some of the best kind of ventilating grates or stoves are made almost entirely of fire-clay and porcelain. Indeed, of whatever material the outside casing may be, all stoves should be lined with fire-clay.

For ventilating stoves it is necessary that the fresh-air channels should be removed from all sources of contamination, such as drains, closets, stables, etc.; and it is advisable to protect the external openings by perforated bricks or gratings. The size of the stove and the sectional area of the air-channel must of course be regulated by the size of the space which is to be warmed and ventilated.

Stove smoke-flues may be either ascending or descending, but in the latter case a pilot-stove or rarefier ought to be fixed at the base of the upright chimney which receives the flue, otherwise the draught may prove faulty. Soot-doors should be provided at all the bends, wherever practicable.

With the ordinary grate, the ventilation of a room may be very greatly improved by providing an entrance into the chimney near the ceiling, and to prevent reflux of smoke, the opening should be valved, as in Arnot's chimney ventilator, or Crossley's noiseless ventilators. One or more openings for the entrance of fresh air could be obtained by inserting perforated bricks or Sheringham valves in the outer walls, also near the ceiling, but at a distance from the fireplace, or by adopting one or other of the several contrivances mentioned in the previous section. Indeed, the mistake which is common to the great majority of houses consists in providing an outlet, generally the chimney, and neglecting to provide inlets, whereas the essential principle of ventilating demands that there shall be at least two openings, one of which shall act as an inlet, and the other as an outlet, according to circumstances.

Instead of an opening leading directly into the chimney for an outlet, a much better plan is to have a flue running alongside the chimney, the entrance to the flue being situated near the ceiling. The hot air in the chimney warms the flue, and there is thus a constant upward current established without any risk of reflux of smoke. But this is an arrangement which can only be attended to in the original plan of a building; it cannot be applied as an improvement afterwards.

Some architects recommend that all the rooms in a well-constructed house should be supplied with warm air from the hall and staircase. In Ritchie's plan the air is heated to about 70° Fahr., and enters the various rooms through longitudinal openings over each door. After being diffused through the rooms, it then passes up the chimneys and through flues reaching from the ceiling to the wall-heads under the roof.

Somewhat similar to this is the plan devised some time ago by Drysdale and Hayward of Liverpool. The fresh air, warmed by a coil of hot-water pipes in the basement, is admitted into a central hall containing the staircase and separate landings, from which it enters the several rooms by suitable openings supplied by valves, and from these again it is conveyed to special outlets in the ceilings, converging to a foul-air chamber under the roof. From this foul-air chamber there is a downcast shaft communicating with the kitchen fire, which is thus made to act as an extraction-furnace.

With regard to these and other complicated methods of house-ventilation, it has to be pointed out that no system is to be commended which dispenses with the opening of windows, occasionally, in order to secure thorough perflation. No doubt, it adds greatly to the comfort of a house if the air in the hall is warmed, and it will also add greatly to comfort if the air thus warmed can be introduced into the rooms by suitable openings; but even in winter the windows should be thrown open for a brief period at least every morning, and in summer, window-ventilation should be chiefly depended on, and the entrance-hall, if louvred in the roof, would act as an extraction-shaft.

Large and compact buildings, such as hospitals, asylums, and prisons, can be very efficiently warmed and ventilated by a suitable arrangement of steam-coils or hot-water pipes. The fresh air, as it enters through openings properly distributed throughout the building, is warmed by passing over the pipes, while the vitiated air may be extracted by means of other coils of heated pipes situated in extraction-

shafts,—a plan which is adopted in the Hôpital Lariboisière in Paris.

For heating purposes, hot water is usually employed at a temperature below 212° Fahr. The boiler is situated at the lowest point, and the outflow and return pipes are respectively connected with the top and bottom of the boiler;—the circulation depending upon the fact that the water in the pipe leading from the boiler is hotter, and therefore lighter, than it is in the return pipe. A feeding cistern and vents for the escape of steam must be provided at the highest points, and the system should be so planned that by means of valves and connecting pipes the hot water may be turned off at given points to permit of "short-circuiting" when required. (See Appendix.)

In Perkins's system the hot water is under pressure at temperatures considerably exceeding 212° Fahr. Strong half-inch iron pipes are used, and a boiler is dispensed with, —part of the pipe being carried through the fire. Steam may be used at high or low pressure in a similar manner.

Another mode of ventilation by extraction, and one which is frequently used in prisons, consists in having a large foul-air extraction-shaft or shafts, heated by a furnace at the bottom, and into which foul-air flues, leading from all parts of the building, are conducted. This system is open to the objection that the currents in the foul-air flues become slighter the greater their distance from the shaft, and in the flues, leading from the farthest parts of the building, the extractive force is practically lost. The column of air in an extraction-shaft may also be heated by gas, or a steam jet may be used as the extractive force.

By a combination of these two methods—viz. heating the fresh air before entering by hot-water or steam pipes, and securing the removal of the vitiated air by flues leading to furnace-shafts or heated extraction-shafts—the largest buildings can be well warmed and ventilated. If necessary, the hot-water pipes may be made to pass through shallow basins of water, to ensure a sufficiency of moisture in the contained air.

Almost all large mines are ventilated on this principle of extraction. By means of a furnace at the bottom of the upshaft, the air is drawn down another shaft and made to traverse the various galleries by an arrangement of partitions and double doors. In well-ventilated mines as much as 2000 cubic feet of air per head per hour can be supplied in this way, and in fire-damp mines, 6000. In some mines the extractive force is exerted by means of a powerful rotatory exhaust fan placed at the top of the upcast shaft, but whatever means may be used it is evident that an enormous volume of air must be passed through the various galleries per hour in order that the impurities of respiration from men and ponies, and products of combustion of lights, and often of blasting, may be removed and constantly replaced by fresh air. In coal-mining the injurious gases given off in gunpowder blasting need no longer be a source of danger to the health of the miner since the introduction of quicklime cartridges, which swell up, when water is poured over them, and exert their force without evolving any deleterious gases. Dynamite, too, is now largely used instead of gunpowder, on account of its greater explosive force, and it is preferable on health grounds, because the gases evolved contain no carbonic oxide, which constitutes $7\frac{1}{2}$ per cent of the gases given off in gunpowder blasting.

In men-of-war and steam-vessels, an iron casing surrounding the bottom of the funnel and upper part of the boilers, is utilised as an extraction-shaft. When the fires are kept burning, so great is the current which rushes up this shaft, that the air can be drawn through the hatchways from all parts of the vessel, and even the hold and timbers ventilated.

In theatres, and other buildings of a similar description, the chandeliers should always be employed to extract the vitiated air. According to the experiments of General Morin, one cubic foot of gas can be utilised so as to cause the discharge of 1000 cubic feet of air. Apart, therefore, from the great advantages arising from the direct removal

of the products of combustion, the aid to ventilation furnished by the extractive power of gas-lights merits special attention, for as a common gas-burner will burn nearly three feet of gas per hour, its extractive power could thus be utilised to remove nearly 3000 cubic feet of vitiated air during the same period. Where a large flood of light is required, the "sun-burner" acts very efficiently in this way, and for smaller rooms or workshops, the "box-top sun-burner" is found to answer very well. The "ventilating globe-light" ought also to be mentioned amongst improvements in this direction. It is so arranged that so soon as the gas is lighted, an upward current is produced in the main tube, and as this becomes heated, the air in the surrounding tube near the ceiling becomes rarefied and set in motion. In this way the heated air in both tubes is carried to a special shaft or to the chimney, thereby securing the removal of the products of combustion and a steady current outwards of the vitiated air in the room.

Extraction by means of a steam jet, and extraction by a fan or screw, are now generally abandoned on the large scale. What is known as the Archimedean-screw ventilator, however, has been lately recommended for small air-shafts, and has also been applied to large factories, where it may be worked by gas or steam power. In mines, the fan has been made to extract as much as 45,000 cubic feet of air per minute. Another fan, known as the Blackman Air Propeller, is very powerful in its action, and can be used either for exhaustion or propulsion. Such fans are especially applicable for the removal of dust in the textile trades, and in dry-grinding.

The system of ventilation by propulsion was first introduced by Desaguliers in 1734. It is carried on by means of a fan enclosed in a box, which can be worked by hand, horse, water, or steam, power. The air enters through an opening in the centre of the box, and is thrown by the revolving fan into a conduit which communicates by proper channels with the different parts of the building. In France and America, the fan is employed in the ventilation

of several of the large hospitals, the air being forced into a basement chamber, where it is heated before it enters the wards. This is known as Van Hecke's system. The ventilation of the Houses of Parliament, Westminster, affords an example of a combined method of propulsion and extraction. By means of fans, air is propelled along conduits to the basement, where it is warmed in winter by passing over steam pipes, and cooled in summer by cold-water sprays or by passing over ice. From the basement it passes through shafts into the space beneath the grated floor of the House, which is covered with a peculiar open coating of whipcord permitting of free passage for the entering air. The vitiated air passes through a perforated glass ceiling in the roof, and is then conducted by a shaft to the basement of the clock tower, where it passes into the flue of a large furnace.

The propulsion or *plenum* system of ventilation and warming is well illustrated in the New General Hospital, Birmingham, which was opened in July 1897. The system adopted is known as Key's system, and has been in successful operation in the Victoria Infirmary, Glasgow, for several years. At four selected points in the basement, the air is drawn through moistened screens to cleanse it from suspended impurities. In cold weather it is then warmed by passing over batteries of steam tubes, and propelled by rotary fans driven by electric motors, along ducts of large sectional area, into separate flues leading into the different corridors, wards, and rooms. In the large wards, the air is principally admitted on both sides in an upward direction through two or more window recesses which are protected by inner glazed sashes to the height of six or seven feet, but elsewhere the air is injected through openings in the walls at a height of about eight feet. The outlets are all at the floor level and communicate by flues to extraction shafts in the roof, whence the air is discharged into the open by means of flapped and louvred turrets. Sufficient power is provided to change the air seven or ten times per hour at a uniform temperature of 60° or 62° Fahrenheit.

There are no other means of warming in any part of the hospital with the exception of the governor's residence and the medical officers' rooms, which are provided with fireplaces. The only parts of the windows made to open are the top-hopper windows.

Amongst systems which owe their efficacy to the mechanical force of water may be mentioned the Eolus Spray Ventilator, and Verity's system. In the former a fly-wheel fitted with fans is made to revolve by the jet of water directed against it, and in the latter the air is set in motion by a spray of water from a number of fine jets. In both systems the rate of motion of the air can be regulated by the tap which supplies the water.

General Considerations.—With regard to the relative position of inlets and outlets, there seems to be some difference of opinion. Theoretically, the inlets for the fresh air should be situated near the floor, and the outlets near the ceiling; but the question of temperature interferes with the practical application of this rule. If the air is not warmed before entering, the inlets should be at least nine or ten feet from the floor, or close to the ceiling, and so constructed that the cold air will impinge against the roof, and fall gently into the room. They should slope upwards to prevent entrance of rain, and should communicate with the external air by means of perforated bricks or gratings, so as to divide the entering current and break its force. With vertical tubes such as Tobin's or Shorland's tubes, the inlets need only reach about six feet from the floor. Sliding covers, valves, or rotatory discs might also be provided, in order that they may be partially or totally closed during rough weather. If the air is warmed before entering, the inlets may be situated, and generally are situated, near the level of the floor. But in either case it is essential that they should be equally distributed throughout the room, to ensure proper diffusion, and that the structural arrangements should permit of their being readily cleaned out, because dirt is sure to accumulate.

The outlets, as already stated, are best situated in or

near the ceiling, not only because air vitiated by respiration tends to ascend on account of its lessened density, but because experiment proves that, given the same extractive power and the same size of outlet, a greater volume of air passes up a flue whose orifice is near the ceiling than up one whose orifice is near the floor. Inlets and outlets should not be situated near each other, otherwise the entering air will be extracted without being first diffused throughout the room.

Outlet tubes, or foul-air flues, as they are generally called, should be smooth, so as not to impede the current of air by friction, and they should be air-tight. When built in external walls as in many prisons I have frequently satisfied myself by experiment that the outside air finds its way into the flue, and sometimes in such volume that though there may be a good current issuing from the top, scarcely any current can be detected entering it at the bottom. I have also found that when the wind beats strongly against the side of a building, with foul-air flues situated in the outer walls, a current of air may actually be issuing from both orifices at the same time. The experiments of Pettenkofer explain how readily such an occurrence may take place, for he has proved beyond doubt that even under ordinary atmospheric conditions, a very considerable interchange of gases takes place through common dry-plastered walls, and indeed, as the sick often experience, very perceptible draughts find their way through outer walls when a stiff breeze is blowing. All foul-air flues, therefore, should be as nearly air-tight as possible, and if they were made of metal tubing, or of glazed earthenware, they would not only satisfy this condition, but would serve greatly to lessen the friction, which is such an impediment to ready extraction through common plastered flues. It is further evident that, when it can be avoided, they should not be situated in external walls, because in cold weather the air becomes cooled as it ascends, and unless the extractive power is very considerable, the increased weight of the column of air by loss of

heat will counteract the extractive force. Where there is no system of artificial extraction, it thus often happens that outlets become inlets, and inlets outlets.

Another very important point remains to be considered, namely, the sectional area of the inlets and outlets. As atmospheric conditions are constantly varying, it is obviously impossible to fix upon any size which will meet every requirement. The only alternative, therefore, is to provide an area that will suit the majority of cases, and which will be capable of being increased or diminished according to circumstances. Parkes has pointed out that in this country a size of 24 square inches for inlet per head, and the same for outlet, is the one best adapted to meet common conditions.

In natural ventilation the volume of air passing through any flue may be calculated approximately by means of what is known as Montgolfier's formula, which is founded on the dynamical law that the velocity in feet per second of a falling body is equal to eight times the square root of the height through which it has fallen. (See Appendix.) In this instance the height fallen is represented by the difference of pressure between the inside and outside air, and this is based on the difference between the inside and outside temperature. Now, as the ratio of expansion of air for every degree Fahr. is ·002 or $\frac{1}{491}$ of its volume, the problem as suggested by De Chaumont may be expressed as follows :—

$$v = 8\sqrt{\frac{(h-h')(t-t')}{491}}$$

where v = velocity in feet per second.
h = height of exit aperture from ground.
h' = height of entrance aperture from ground.
t = temperature of inside air.
t' = temperature of outside air.

The velocity per second multiplied by the sectional area of the flue in feet, or decimals of a foot, will give the number of cubic feet of air ascending the flue per second. But a considerable allowance, varying according to circum-

stances from one-fourth to one-half, must be made for friction; while another element of error creeps in which cannot be estimated, inasmuch as the movement of air in all flues is greatly influenced by the varying force of the wind. The loss by friction in tubes or flues of similar size and sectional area will be directly as the length of tube or flue, and if they are dissimilar in size it will be inversely as the cross section of each. Then, again, the amount of loss by friction depends greatly upon whether there are any bends in the tube or flue, and whether it is circular, inasmuch as a circle is the figure which includes the greatest area within the smallest periphery. (See Appendix.)

It may be said generally that though natural ventilation is less costly, it is inconveniently subject to atmospheric conditions, and is inadequate for the efficient ventilation of crowded buildings, such as schools, churches, theatres, and the like. The advantages of mechanical ventilation, on the other hand, are its constancy under all conditions when properly devised, and the facilities which it affords for regulating the volume of fresh air delivered, and for permitting facilities for its preparatory treatment as regards temperature, moisture, and purification.

In his well-known report to the School Board of Dundee in 1889, the late Professor Carnelly estimated that the cost per head to ventilate a school to accommodate 1000 children, and also to warm it, may be put down at $2\frac{3}{4}$d., while on the artificial system it would amount to about $7\frac{1}{2}$d., representing a total difference of about £20—a very small expenditure to secure such highly desirable results. The plan of ventilation which he recommended, after investigating several methods in use, was propulsion by means of a fan or fans, driven by a gas-engine, and he also recommended that the fresh air should be filtered through coarse jute cloth.

Schools of moderate dimensions are perhaps best warmed and ventilated by means of hot-water pipes, with the addition of ventilating grates when required. Small schools can be best warmed and ventilated by ventilating grates or stoves.

A few remarks may now be added with regard to *Lighting.* Daylight illumination in respect to living rooms, workshops, factories, and schools is a matter of prime importance to health and comfort. In schools the area of the window-space should be not less than one-tenth and not more than one-fourth of the floor space. The school-room should preferably be of oblong shape, with the windows on one of the longer sides only, because cross-lights should always be avoided as far as possible. The desks should be at right angles with the windows, and so arranged that the scholars may sit with the windows on their left.

With regard to artificial lighting, it may be said generally, that the commonest method of illumination depends upon the combustion of inflammable vapours or hydro-carbons, whether derived from coal-gas, oils, or candles. In coal-gas illumination, various kinds of burners have been devised to increase not only the luminosity but the steadiness of the flame. Many of the common kind of burners, such as the "fish-tail burner" or the "bat-wing burner" do not ensure complete combustion, and are apt to flare up when there is any increase of pressure. The improved "Argand burner," which is circular and must be enclosed in a glass chimney, gives a much steadier and softer light, and ensures much more complete combustion. Other burners, as already pointed out, have been devised to assist very materially in ventilation, such as the "sun-light burner" and the "globe-light burner." What is known as Siemens's "regenerative gas burner" not only gives a brilliant light, but is so arranged with ventilating tube that the products of combustion can be conveyed into the outer air. It is well adapted for lighting large halls and public buildings, and for street lighting. The Welspach "incandescent gas burner" consists of a Bunsen burner with an asbestos gauge mantle treated with sulphate of zirconium. This mantle is suspended in the flame, and becoming incandescent yields a very bright light, and much whiter than the ordinary gas flame. Both flame and curtain must be enclosed in a glass chimney.

In order to equalise pressure throughout the gas-pipes in a house, what are called gas governors or regulators are employed and are placed near the meter. These are so constructed that when there is increased pressure, the lumen through which the gas passes is narrowed by the automatic action of valves, and when the pressure is diminished the lumen is widened. Single burners on the self-regulating principle have also been devised which answer very well.

Kerosene, the mineral oil commonly used for lamps, is distilled from crude petroleum. It gives off an inflammable vapour which ignites at varying temperatures, according to the quality of the oil. This temperature is called the flashing point, and by Act of Parliament it must not be lower than 100° Fahr., to prevent risks of explosion. Vegetable oils, such as colza oil, do not give off inflammable vapours, but they are much dearer than mineral oils, and their illuminating power is less. Candles, and especially the commoner sorts, give off considerable quantities of unconsumed carbon.

Electric lighting is rapidly coming into use, and apart from its superior illuminating properties it possesses several sanitary advantages over other illuminants, inasmuch as there is no oxygen consumed, no products of combustion thrown off to pollute the air, and the heat produced is very trifling. Moreover, the light is not yellow, but white, and resembles solar light. For domestic lighting, incandescent lamps are the most suitable.

CHAPTER V

EXAMINATION OF AIR AND VENTILATION

A DETAILED examination of the sufficiency of ventilation in any particular case will embrace the following inquiries :—

1. The arrangements as regards space, the relative size of inlets and outlets, the distribution of the air, and the amount of fresh air supplied.
2. The examination of the contained air by the senses.
3. Chemical examination of the contained air.
4. Microscopical and bacteriological examination of suspended impurities.
5. Examination as regards temperature, moisture, etc.

SECTION I.—EXAMINATION AS REGARDS SPACE AND VENTILATING ARRANGEMENTS

To ascertain the exact size of a room, it is necessary first to calculate the floor space, and afterwards the cubic space. If a room is oblong, and has a flat ceiling, the only measurements required are the length of the room, the width, and the height. The width and length multiplied together will give the superficial area or floor space, and this multiplied by the height will give the cubic space. But it very often happens that rooms are of irregular shapes with the sides neither parallel nor at right angles to each other, or there may be projections or recesses, angular or circular, while the ceiling may slope, either partly or altogether, or be dome-shaped. Or a room may be circular, such as a circular ward, or shaped like a

truncated cone or pyramid, such as is sometimes found in the towers of modern-built mansions and hotels. In mostly all these cases it will be necessary to divide the room into sections, and apply the rules for the measurement of these sections.

The more important of these rules may now be given, and first as regards area or superficies :—

Area of square . . . = Square of one of the sides.
Area of rectangle . . = Multiply length by width.
Area of triangle . . = { Multiply base by one-half height, or height by one-half base.
Area of any figure bounded by straight lines = { Divide into triangles and take the sum of their areas.
Area of circle . . = { Multiply square of diameter (D^2) by ·7854, or square of circumference (C^2) by ·0796.
Circumference of circle . = $D \times 3{\cdot}1416$.
Area of an ellipse . . = { Multiply the product of the two diameters by ·7854.
Area of segment of circle = { To two-thirds of the product of chord and height add the cube of the height divided by twice the chord $= \frac{2}{3}(Ch \times H) + \frac{H^3}{2Ch}$.

As regards cubic capacity, the following rules or examples may be given :—

Cubic capacity of a cube or solid rectangle = { Multiply together the length, width, and height.
Cubic capacity of a solid triangle = { Multiply area of section (triangle) by depth.
Cubic capacity of a dome . = { Multiply area of base by two-thirds height.
Cubic capacity of a cylinder . = { Multiply area of base (circle) by height.
Cubic capacity of a cone or pyramid. = { Multiply area of base by one-third height.

In estimating the cubic capacity of a bell-tent, the capacity may be taken as that of a cone, or of a cone resting on a short cylinder. In estimating the cubic capacity of a marquee, or of a circular building with dome, or of a room irregularly shaped, it will be necessary to

divide into sections, and calculate the results of the various measurements separately.

After the cubic capacity of the room has been ascertained, corrections must be made for the larger pieces of furniture, bedding, etc., and for inequalities in the contour of the space. For instance, the displacement caused by solid projections into the room must be deducted, and the cubic contents of open recesses added. The allowance for each bedstead may be put down at 10 cubic feet, and for the space occupied by the body of each adult person at 3 cubic feet. After all these corrections have been made, it is of course an easy problem to ascertain the cubic space per head, though so far as practical ventilation is concerned, any space higher than 14 feet ought not to be taken into account in respect to living rooms or dormitories, but all the measurements should be noted and the total cubic capacity ascertained.

The next points to be inquired into are the relative position of inlets and outlets. Perforated bricks and gratings can be approximately estimated as regards their total open sectional area by taking their actual superficial area and calculating the relative size of the interstices. Inlets should be inspected as regards their freedom from accumulation of dust, etc., and outlets as regards the presence of any impediments to the ready exit of the vitiated air. Where there are open fire-places, the sectional area of the smoke flue must also be ascertained. The existence or otherwise of unpleasant draughts, and the relative position of doors and windows, and how far they assist in the ventilation of the room, are other items which must not escape notice. If the system of ventilation is artificial it should be examined in all its details, and in this examination great assistance will be derived from inspecting the architect's plans, whenever they can be procured.

The directions of air-currents in a room can be ascertained by means of the smoke from smouldering cotton velvet, fibres of floss-silk, small pieces of feather, small balloons filled with hydrogen gas, etc. The flame of a candle is often used for the same purpose, but it is of no

value when the currents are delicate, because it is unaffected by them, but is of considerable service in showing whether air is entering or issuing through any opening. Very frequently, as has already been pointed out, openings that are meant to be inlets act as outlets, and *vice versa*, or the movement of air in them may be unstable, intermittent, and reversed in its action, now entering and now issuing through the same opening.

All these points, and others which may arise from peculiarities of structural arrangement, should be carefully inquired into, and the various measurements and observations noted down as they are made. When the ventilation is intended to be carried on independently of open doors and windows, these should be closed during the examination.

In determining the rate of movement through the various openings, an instrument called an anemometer, such as Cassella's, is generally used, which indicates on a dial-plate the linear dimension of the air current in feet, hundreds of feet, etc., and when this is multiplied by the sectional area of the opening, the volume of air which has passed through in any given time can be easily calculated in cubic feet. When the instrument is placed in a tube or shaft it should be put well in, but not quite in the centre, because the velocity of the current in the centre is greater than at the sides of the tube. Should the shaft be large the rate of movement ought to be taken at different parts and the average ascertained. So also, when the rate of movement is irregular, several observations should be made, and the average of the whole of them will give the approximate velocity of the current. If placed in a tube whose sectional area exceeds but very little the space occupied by the revolving sails, the results cannot be depended on; and when placed at the entrance of a tube, as for example, against a perforated air-brick or grating, the velocity of the current indicated by the anemometer is considerably less than what exists in the tube. In these cases the instrument should be exactly fitted into an opening in a box large enough to cover com-

pletely the mouth of the tube, by which means the whole of the air passing through the tube may be made to pass through the opening in the box.

The amount of air found to be issuing up chimneys or other outlets is a far more reliable index of the fresh-air supply than the amount actually ascertained to be entering through the inlets; and indeed the fresh-air supply can only be fairly estimated in this way. As already stated, the air enters through every chink and cranny, and in dry plastered walls may enter, to no slight extent, through the walls themselves. Hence the difference between the amount of air found to be entering through the regular fresh-air inlets and that found to be issuing through the outlets is often very great. In a ward containing 15 beds, with one door, eight windows, and four inlets for fresh air, I have found that while only 880 cubic feet of fresh air were entering through the inlets per bed per hour, as much as 3150 were found to be issuing up the two chimneys and the three extraction flues of the ward. During the experiments the door and windows were shut, and brisk fires kept burning in the two ventilating fire-places. The large amount, therefore, of 2270 cubic feet per bed per hour entered through chinks in the window-frames, and beneath and around the closed door. Very probably, in this instance, a considerable amount was also drawn by the extractive force of the chimneys and flues through the walls, inasmuch as they were built of brick, and were only whitewashed and not plastered.

When an examination of the respired air itself is intended, a suitable time must be selected during which all the conditions of the efficiency of the ventilation, in any given instance, can be fairly put to the test. Take a hospital ward, for example. It is necessary that all the beds should be occupied, that windows and doors be kept shut, if ventilation is intended to be effectually carried on without them, and that an hour should be selected in the night-time when the greatest accumulation of impurities is likely to occur. Any hour between midnight and 5 A.M.

would meet this condition in most cases. In order to make the examination as complete in detail as possible, it is necessary to have a wet and dry bulb thermometer placed outside some time previously, and several others fixed at different positions in the ward. The outside and inside temperature can thus be compared, and the relative hygrometricity of the air indoors and outdoors ascertained. If the barometer is read off at the same time, and the state of the weather recorded, all the meteorological data are obtained which are usually considered necessary for a full and exhaustive report.

Section II.—The Examination of the Contained Air by the Senses

With a little practice, this method of examination gives tolerably reliable results; but it is necessary that one should remain for some short time in the open air, before entering the ward or room to be examined, otherwise the sense of smell is likely to be blunted and unable to appreciate the degree of closeness or foulness. One of the terms "not close," "rather close," "close," "very close," "foul," "very foul and offensive," will indicate, with sufficient accuracy, the degree of perceptible impurity in the majority of cases. The following selections from De Chaumont's experiments show how closely the sensations accord with the different degrees of impurity indicated by the percentage of carbonic acid:—

At ·1408 per cent	Extremely close and unpleasant.	At ·0843 per cent	Not very foul.
„ ·1090 „	Extremely close.	„ ·0804 „	Close.
„ ·0962 „	Very close.	„ ·0658 „	Not very close.
„ ·0921 „	Close.	„ ·0568 „	Not close.

Section III.—Chemical Examination

1. *Carbonic Acid.*—In the chemical examination of respired air, the chief point to be determined is the amount of carbonic acid per 1000 volumes. Pettenkofer's method

is the one most generally adopted, because it is alike accurate and easy of application. For the analysis, which is volumetric, French weights and measures are used. The following apparatus and solutions are also required :—

(1) Two or more glass jars, each capable of holding 4000 to 6000 c.c., and fitted with india-rubber caps.

(2) A Mohr's burette, graduated into c.c. and tenths, fitted with pinch-cock, and large enough to hold 50 or 100 c.c.

(3) A narrow glass measure, marked to measure 30 and 60 c.c. exactly.

(4) A pair of bellows or a bellows-pump.

(5) Turmeric paper specially prepared. (Turmeric powder should be boiled in alcohol, and ordinary filtering paper steeped in it, then washed and dried.)

(6) Pure, clear, lime water saturated, or nearly so.

(7) A solution of crystallised oxalic acid, 2·25 grammes to the litre of distilled water.

The capacity of the glass jars must be accurately determined by means of a litre measure graduated into c.c., and it is convenient to affix the cubic contents, expressed in c.c., to each jar. Before being used it is necessary that the jars should be perfectly clean and dry.

The analysis depends on the relative degree of causticity of the lime water before and after it has absorbed the carbonic acid contained in the sample of air to be examined. 1 c.c. of the above solution of oxalic acid exactly neutralises 1 milligramme (·001 gramme) of lime. Thus, taking the atomic weights—

$$\text{lime } CaO = 56$$
$$\text{oxalic acid } C_2H_2O_4 + 2H_2O = 126$$
$$\text{and } 56 : 126 :: 1 : 2{\cdot}25.$$

If therefore 2·25 grammes of oxalic acid are dissolved in 1 litre of pure distilled water, 1 c.c. of the solution = 2·25 milligrammes of oxalic acid, which will exactly neutralise 1 milligramme of lime to form oxalate of lime. Hence the amount of lime contained in a given quantity

of lime water can be readily determined by adding the solution until the point of neutralisation is reached. The amount of oxalic acid solution required for neutralisation expresses the causticity or alkalidity of the lime water. If now the causticity of the lime water is known before and after it has absorbed the carbonic acid in the air contained in the glass jar, the difference will give the amount of lime in milligrammes which has united with the carbonic acid, and the amount of the latter is obtained by calculating according to the atomic weights.

The amount of neutralisation is determined by means of the turmeric paper. The test solution of oxalic acid should be run into the measured quantity of lime water from the burette, and the mixture constantly stirred with a glass rod. Every now and again a small drop of the mixture is conveyed on the tip of the rod to the turmeric paper, and one can readily judge by the tint of the stain when the point of neutralisation is approached. With pure lime water the stain produced is an intense dark brown, and as the oxalic acid solution is added, it becomes gradually paler on each application, until at last the centre of the stain is not tinted, and the margin alone appears as a delicate brown ring. The solution should now be carefully added drop by drop, and when the tint of the ring also disappears, the point of neutralisation has been reached. Another method of testing is to add a few drops of a solution of phenol-phthalein to the lime-water which becomes decolorised as soon as the lime is neutralised by the oxalic acid solution.

In making a single analysis it is advisable to use two jars, because otherwise a repetition of the experiment would not be possible were it required. Under ordinary circumstances, however, as many analyses can be made as there are jars used for collecting samples of the air from different parts of the same room or building. The air to be examined is forced into the jars by means of a pair of bellows, and, by a suitable arrangement of tubing connected with the bellows, it can be pumped into them from any

part of the room. In the case of small occupied spaces, such as prison cells, when it is not desirable to disturb the ventilation by opening the door, the contained air can in this way be pumped into the jars through any opening, such as the inspection hole in the door,—care being taken that the tubing and its connection with the bellows are perfectly air-tight, and that the bellows-valve acts efficiently.

Instead of bellows, a bellows-pump may be used, but in either case the nozzle should be long enough to reach the bottom of the jar. When it can be conveniently done, the best plan is to fill the jar with clean water and empty in that part of the air-space which it is desired to examine, and taking care that it drains well.

After the jar has been filled, 60 c.c. of lime water are introduced, and the mouth of the jar closed by a tight-fitting india-rubber cap. If tubing has been used to convey the air from a distant part of the room, or from a small inhabited place without entering it, it is necessary that this part of the experiment should be performed rapidly, in order to prevent escape by diffusion, and therefore the measured quantity of lime water should be ready to be poured into the jar whenever the nozzle of the bellows is withdrawn. The jar is then well shaken, so that the lime water is made to wash the contained air thoroughly, and afterwards is left to stand for a period of not less than six or eight hours, and not more than twenty-four. 60 c.c. are introduced, in order that 30 may be taken out for analysis. So much of the lime water adheres to the sides of the jar that the whole amount introduced cannot be poured out; and hence, if a repetition of the experiment is necessary, another jar must be used.

In making the analysis, 30 c.c. of the lime water which has been employed are poured into a mixing jar, and its causticity determined as above described by the test solution. Then 30 c.c. are taken from the jar, and the causticity also determined. The causticity of the lime water is found to vary from 34 to 41, according to its

strength: in other words, from 34 to 41 c.c. of the oxalic acid solution will be required for neutralisation, while the causticity of the lime water in the jar will be lessened in proportion to the amount of carbonic acid in the contained air. The difference between the first and second operations is doubled to account for the 30 c.c. left in the jar, and the product gives the amount of lime which has combined with the carbonic acid. The amount of the latter, as already observed, is obtained by converting weight into measure according to the atomic weights, and in one sum the factor is found to be ·3975.

Thus CaO = 56, and CO_2 = 44

and 56 : 44 :: 0 (mgm. CaO) : X (mgm. CO_2).

But as 1 c.c. of CO_2 at 32° Fahr. weighs 1·3767 mgm. the ratio between volume and weight is $\frac{1}{1 \cdot 9707} = \cdot 5059$.

Therefore $X \times \cdot 5059$ = c.c. of CO_2, and $\frac{44}{56} \times \cdot 5059 = \cdot 3975$.

The capacity of the jar being known, and a deduction of 60 c.c. made for the space occupied by the lime water, the amount of carbonic acid becomes a question of simple proportion. Thus, to take an example—Suppose the causticity of 30 c.c. of the lime water is 39·5, and the causticity of the lime water in the jar is 33·5; suppose also that the capacity of the jar is 5060 c.c.; then, to find the ratio of carbonic acid per 1000 volumes, that is, per 1000 c.c., the problem is as follows:—

$(5060 - 60) : 1000 :: [(39 \cdot 5 - 33 \cdot 5) \times 2 \times \cdot 3975] : X$;

therefore $X = \frac{6 \times \cdot 795}{5} = \cdot 954$ carbonic acid per 1000 volumes.

It will thus be seen that the calculations may be simplified by adopting the following rule:—Multiply the difference between the causticity of the lime water, before and after it has been placed in the jar, by 795, and divide this sum by the number of c.c. contained by the jar, *minus* 60. The result will be the ratio of carbonic acid per 1000 volumes.

But a certain correction must be made for temperature, according as it is above or below the standard of 32° Fahr.

As the co-efficient of expansion of air is ·0020361 for every degree Fahr., the rule for correction may be stated with sufficient accuracy thus:—For every 5° above 32° add 1 per cent to the amount of carbonic acid calculated as above, and deduct the same percentage for every 5° below 32°. Or, to put it more correctly:—Suppose that in the above experiment the temperature of the air is 57° Fahr. Then $57° - 32° = 25$, and $25 \times ·002 = ·05$ per cent to be added. In other words 100 vols. at 32° become 105 vols. at 57°, or 1 vol. becomes 1·05.

Therefore 1 : 1·05 :: ·954 : 1·001 per 1000.

If the place of observation is much above the sea-level, a correction must also be made for the difference of atmospheric pressure. The standard barometric pressure being 29·92, the formula for this correction is as follows:—29·92 : (observed height of barometer) :: capacity of jar : Z. The result expressed by Z is substituted for the actual capacity of the jar in the calculation for carbonic acid.

Baryta water is often used instead of lime water, because the whole experiment takes much less time, and can be done under the hour.

Among other methods for determining the amount of carbonic acid in respired air approximately, and very readily, perhaps the best is that of Lunge and Zeckendorf. This requires a solution of carbonate of soda 53 grammes to the litre, coloured crimson with ·02 gramme of phenol-phthalein. 10 c.c. of this solution are placed in a flask so arranged that the air, which is pumped in by an india-rubber pump of 70 c.c. capacity, is made to pass through the solution. The air is slowly pumped through until decoloration is complete, and the number of fillings or pump-fulls noted. This minimetric apparatus has been standardised by the Pettenkofer process, and a table prepared in which the number of fillings of the pump required to decolorise the solution represents a certain percentage of CO_2 in the air to be examined. Exclusive of the test solution, the whole set, neatly put together in a case, costs very little.

2. *Carbonic Oxide* (CO).—Unfortunately there is no very

convenient test for the presence of this gas. It may, however, be determined quantitatively by exposing a measured volume of air to a solution of cuprous chloride in strong hydrochloric acid, which absorbs the gas, and the loss in volume would indicate the amount of CO present.

3. *Sulphuretted Hydrogen* may be detected in small quantities either by exposing pieces of paper soaked in lead acetate to the air, or by passing air through a solution of this salt, when a dark or black colour is produced.

4. *Ozone.*—The various tests which have been recommended for detecting or estimating the presence of ozone are all more or less imperfect. Perhaps the most reliable test is to expose strips of iodised litmus paper to the air, when the greater or less conversion of the red litmus into blue, shows a greater or less quantity of ozone present. Scales have been prepared for estimating the amount of ozone as indicated by the depth of colour.

5. *Organic Matter.*—The best method of estimating organic matter in the air is to draw a known volume of air through a little distilled water by means of an aspirator, and then estimate the quantity absorbed by the amount of oxygen consumed as determined by the Forschammer process (see Chapter on Water Analysis).

6. *Ammonia* is also collected by aspirating a known volume of air through distilled water, and then determining the amount quantitatively as in ordinary water analysis.

Section IV.—Microscopical and Bacteriological Examinations

The best method of collecting dust or suspended impurities, for examination, is to use a large aspirator of known capacity, and draw the air through a tube at least one inch in diameter packed for two inches of its length with crystals of sugar or sodic sulphate. At the conclusion of the experiment this soluble filter is dissolved in distilled water, filtered through a small weighed filter, the filter washed, dried, weighed, and the weight noted as so much per cubic foot.

This will indicate the amount of dust present, and the dust thus collected may be examined microscopically. In the same way if the water used for dissolving the filter has been carefully sterilised by boiling, the bacteriological indications of the impurities may be ascertained by cultivating in prepared nutrient media.

For the mere qualitative examination of dust and organisms, the air may be drawn through distilled water, or Pouchet's aeroscope may be used. This consists of a funnel-shaped tube ending in a fine point, beneath which is placed a slip of glass moistened with glycerine, on which the suspended matters are collected. Or Hesse's method may be followed. In this the air is drawn through a tube which has been previously sterilised, the inside of which is smeared with nutrient gelatine, and on this medium moulds, fungi, and micro-organisms can be cultivated and examined. Dr. Percy Frankland recommends that the air be aspirated through a glass tube in which are two plugs of sterilised glass wool which are afterwards introduced into a flask containing melted nutrient gelatine, and well shaken up. This solidifies on the sides of the flask, and the colonies which develop can be examined by means of a lens through the glass.

Section V.—Examination as regards Temperature and Moisture

1. *Temperature.*—The various points connected with the temperature of the contained air, such as its equability, sufficiency, etc., are readily ascertained by a judicious distribution of thermometers throughout the space to be examined, and by comparing the outside with the inside temperature. The efficiency of the heating apparatus is of course best tested during very cold weather, and in the night-time. When open fire-places are used the temperature should be noted at the remote parts of the room, and if the air is heated before entering, it is advisable to take the temperature at the point of delivery, and to ascertain whether it is well diffused or not.

2. *Moisture.*—The amount of watery vapour, or the hygrometricity of the contained air, may be determined by hygrometers such as Daniell's and Regnault's, or by wet and dry bulb thermometers. The latter are the most convenient and reliable, but they should be distributed some two or three hours before the observations are made.

Unless the air is saturated with moisture, the temperature of the wet bulb is always below the temperature of the dry, and the number of degrees of difference between them varies according to the amount of watery vapour present. This is generally represented in relative terms. For example, the point of complete saturation being assumed to be 100, any degree of dryness may be stated as a percentage of this, and can be conveniently ascertained by reference to Mr. Glaisher's tables.

The relative humidity of the air out of doors should also be ascertained at the same time by way of comparison.

In carrying out experiments in ventilation, the hair-hygrometer gives sufficiently accurate results, and possesses a considerable advantage over the dry and wet bulb thermometer in rapidity of indication (see next Chapter).

In a room well ventilated and warmed the humidity ought to range between 73 and 75 per cent., the temperature should not fall below 60° Fahr., and the carbonic acid, as previously stated, should not exceed 0·6 per 1000 volumes.

In the examination of the air contained in the crowded dwellings of the poorer classes, the senses will alone sufficiently indicate the degree of impurity, but in all cases the cubic space per head, and the means of ventilation, should be carefully noted, because otherwise any suggestions as regards improvements will at the best be hap-hazard, and possibly ill-advised.

CHAPTER VI

CLIMATE AND METEOROLOGY IN THEIR RELATIONS TO PUBLIC HEALTH

SECTION I.—CLIMATIC AND METEROLOGICAL CONDITIONS

THE term climate may be defined as the combined effect of the atmospheric and telluric conditions which determine the suitability of various localities for the maintenance of animal and vegetable life. Apart from the chemical composition of the atmosphere, the most important factors of climate are the temperature of the air, its density, its humidity, its circulation as represented by winds, the amount of light which it distributes, and its electrical conditions. So far as the climate of any particular locality is concerned, these factors are determined by the distance of the locality from the equator; its elevation above sea level; its relative position to seas, inland lakes, deserts, flat plains, or mountainous regions; and its geological and topographical features generally. In addition to these there are many other modifying influences which go to form what are called local climates, such as the cultivation of the land, drainage of the subsoil, the planting of trees, the clearing of forests, the crowding together of dwellings, and the establishment of manufactories.

Various classifications of climate have been attempted by different writers, but all of them are more or less arbitrary and necessarily imperfect. As temperature, however, is beyond all doubt the most important factor in the determination of climate, most classifications have been based on

this consideration, and the simplest, perhaps, is that which recognises three principal kinds of climate, namely, warm climates, extending from the equator to 35° lat.; temperate climates, extending from 35° to 55° lat.; and cold climates, extending from 55° to the poles. These again may be subdivided into equatorial, tropical, sub-tropical, sub-polar, and polar; while, according to geographico-physical conditions, they may also be divided into insular and maritime, and inland or continental climates.

In considering climatic conditions it will be convenient to refer briefly to the physical features of the atmosphere on which they principally depend.

1. *Temperature.*—As solar heat is the source of all energy, so it exercises supreme control over climatic conditions. What is called radiant heat, or the heat radiated from the sun, although it possesses great power of warming solid and fluid bodies on which it falls, has little power of heating the air through which it passes. Indeed, were it not for the watery vapour contained in the atmosphere, pure air would be diathermic or transcalent;—in other words, radiant heat would pass through it without raising the temperature. It is the shade heat, or the heat reflected from the surface of the earth, whether land or water, and directly warmed by the radiant heat emanating from the sun which regulates the temperature of the air. This shade heat, however, is greatly modified by winds, by the relative extent of land and water, by mountains, and by topographical conditions generally. Winds, for example, convey over immense distances the temperature of the regions from whence they arise, while owing to the greater specific heat of water, which is as 4 to 1 compared with that of land, water takes longer to warm as well as to cool. Hence the sea, remaining open, excepting in the polar regions, is constantly modifying the strata of air coming in contact with it, and thus moderates the heat in summer and the cold in winter. It is on account of this specific heat of water that insular climates are more equable than continental—the summers cooler, and the winters warmer.

The effect of elevation in lowering temperature depends upon the fact that as heat is very slowly communicated from stratum to stratum of the air, and as the air is warmed chiefly by the surface of the earth, the lowest layers are the warmest, and the temperature on mountain tops is therefore much lower than on the plains below. This difference, however, is far more marked in the daytime than at night, and in summer than in winter. In fact, during severe frosts the conditions are generally reversed, and the temperature rises with height instead of becoming lower, so that a thaw may often be seen setting in on the hills while the frost is unbroken in the valleys below. If the air were perfectly dry, the rate at which the temperature would fall would be 1° Fahr. for every 180 feet ascent; but as the atmosphere contains moisture which is liable to be condensed by cold, the latent heat given out in condensation diminishes the rate of cooling, so that the rate of lowered temperature as a general rule may be taken at 1° Fahr. for every 300 feet in altitude. Indeed, apart from elevation, the chief effect of mountain ranges is to deprive the winds passing over them of the watery vapour which they convey. Hence the leeward sides of mountain ranges have colder winters and warmer summers, because the screen of vapour which would otherwise protect them from excessive heat or excessive radiation is removed. The greater rainfall of our own western, and the greater dryness of our eastern, shores, are due to a similar agency.

2. *Atmospheric Pressure.*—The weight of the air at the earth's surface is equal to a pressure of about 15 lbs. on every square inch of surface. If the density of the atmosphere were uniform throughout, its height would not exceed a limit of five miles; but as air is elastic and does possess weight, it is evident that the layers beneath must be more compressed than the layers above, and that the greater the height, the lighter and more rarefied must these layers become, so that the limit of the atmosphere has been variously estimated to extend to a height of from 50 to 200 miles. The indications of the mercurial barometer merely

represent the fact discovered by Torricelli in 1643, that a column of mercury of about 30 inches in height balances a column of air of the same thickness, but extending to the height of the atmosphere. As the pressure of the atmosphere varies from day to day, and even from hour to hour, the height of the mercurial column is subject to corresponding fluctuations. Indeed, the great use of the barometer is to indicate these changes of pressure, which are of special importance to the meteorologist, because they point to changes in the winds; and these are the prime agents in effecting changes in the weather.

3. *Movement of Air and Winds.*—As has already been pointed out, one of the effects of the warm sunbeams falling on land and sea, and of the heat radiated from them, is to warm the layers of air which successively come in contact with the surface; and as they are thus rendered lighter they ascend, and thereby produce upward currents. From the latitudes round the equator, these heated currents of air, after ascending and during their ascent, flow northwards and southwards to the polar regions. During their course they become colder and condensed, and therefore sink towards the earth, again returning towards the equator to complete their round of action. But all the while the earth's surface is revolving from west to east at a rate of 1000 miles an hour at the equator, and at a lower rate of rotation according to latitude, until at the poles the velocity is reduced to zero, because the poles simply represent the ends of the axis on which the earth rotates. Moreover, as the atmosphere may be regarded as a gaseous shell which completely encases the globe, it necessarily shares in all its movements, and therefore moves round at the same rate as the surface on which it rests, and therefore the atmosphere, while quiescent over the poles, moves with increased rapidity in lower latitudes, until at the equator it attains a speed of 1000 miles an hour. Hence the currents of air which, as we have seen, are continually flowing from either pole in a direct south and north line, will constantly tend to lag behind the surface of the earth as they move towards the equator. Thus the current

starting from the north pole, as it passes south, acquires a relative motion from east to west, and as a resultant of the two motions, that from the north with that from the east, the wind thus produced would seem to come from the north-east; in other words, it would appear as a north-easterly, and not as a northern, wind. In this way it comes about that winds, more or less constant in direction, blow across those parts of the Atlantic and Pacific Oceans which lie for some distance on the two sides of the equator; the direction being from the north-east in the northern tropics, and from the south-east in the southern tropics. These winds, which were of so much importance to navigation before the days of steam-ships, were therefore called the *trade* winds. Although these winds are more or less constant, they are greatly modified by local circumstances, such as the distribution of land and water, the character of the sea-shore, and the altitude of the more inland regions. They are not equally marked in the two great oceans, nor are they equally strong at all seasons.

On the other hand, it will be readily understood that the air which rises from the heated equatorial belt, on reaching the higher regions of the atmosphere, flows northwards and southwards towards the polar regions over the currents which are sweeping across the surface below. But these upper currents are blowing from regions of high velocity to regions of lower velocity of rotation, and consequently they move more rapidly in the direction of the earth's rotation than the surface immediately beneath them. Hence they are deflected from a simple north and south course, but in an opposite direction to that of the trade winds, so that in the northern hemisphere they become south-westerly winds and in the southern hemisphere they blow from the north-west. Such upper currents, moving in an opposite direction to the surface winds, may be recognised by their effects on high clouds. In the higher regions of the atmosphere they become chilled, and at about the thirty-fifth degree of latitude they become sufficiently condensed to descend to the surface. Part of the air then returns as an undercurrent to

the equatorial belt, where it again ascends to complete its circulation in this region of the atmosphere, while another part of the descending air continues its course as a south-west wind in the northern hemisphere, and as a north-east wind in the southern hemisphere, but these winds are not so constant as the trade winds. The prevalent south-west winds of this country partake partly of this origin, and as they are laden with moisture they are the chief rain-bearers of the British Isles.

But the diurnal rotation of the earth exercises other effects on the circulation of the air, and as a notable instance what is known as the land-and-sea breeze may briefly be noticed. As the sun's heat warms the surface of the land more rapidly than the surface of water, the layers of air which come in contact with it are more quickly heated, and therefore ascend, and are replaced by the colder currents flowing inward from the sea. During the night, however, the current is reversed, for while the surface of the sea remains at pretty much the same temperature as during the day, the surface of the land radiates or gives off heat more rapidly and becomes cooled, and hence the breeze blows seaward. As regards other winds, however much they may vary in force or direction, they are all originated in the first instance by solar heat,—their variety being accounted for by the rapidity of the motion of the earth's surface at various latitudes, by differences of temperature, by unequal distribution of land and water, and by local peculiarities, such as mountains, valleys, or far-reaching level plains.

4. *Humidity.*—Another most important function which the atmosphere discharges in relation to life and health is to act as nature's water-carrier; and here again the sun is the active agent, for the action of solar heat upon water is to convert it into vapour. Hence over the vast surfaces, more especially of equatorial seas, a process of distillation is incessantly going on;—the watery vapour laden with the heat absorbed in its production is carried up by the air currents just described, and may thus be wafted thousands of miles before it becomes condensed and falls to the earth.

Indeed, we in this country are chiefly supplied with water distilled from the seas which lie between the tropics, and, moreover, we owe in great measure the mildness of our climate to the latent heat conveyed by this watery vapour, and which is again set free when it becomes condensed to fall to the earth as rain or snow.

It need hardly be said that the amount of watery vapour present in the air is constantly varying, and the amount varies according to the temperature. Indeed, the higher the temperature the greater the quantity of water which may exist in the state of vapour; in other words, the capacity of air for containing watery vapour increases in direct proportion to its temperature.

The quantity of vapour contained in a given amount of air is called the *absolute humidity*, while the proportion of vapour actually present in the air to the amount which it would contain when fully saturated is called the *relative humidity*. When we speak of dry air, and humid or moist air, it is meant that the relative humidity is low or high. The degree of the former varies with the seasons, being higher in summer than in winter; whereas the latter generally follows an opposite course, being lowest mostly in May and June, and highest in December and January. When, therefore, the temperature of the air becomes lowered, the relative humidity rises, and if this continues up to saturation, condensation of vapour occurs, which on solid bodies shows itself as dew, or in the air itself, as mists or clouds. When further condensation takes place under the influence of still lower temperature or increased barometric pressure, the clouds are transformed into rain or snow.

The conditions on which the amount of rain depends are partly general, such as degree of latitude and elevation above sea level; and partly local, as nearness of large surfaces of water, exposure to moist winds, or proximity to mountain ranges. As a rule, the amount of rainfall decreases with increasing distance from the equator, but this rule has many exceptions. Moreover, the amount of rainfall in different regions is not proportionate to the humidity of the air, inas-

much as a region may almost be rainless in spite of a humid atmosphere, if there are no cold winds to produce condensation; while, on the other hand, localities with considerable rainfall may enjoy tolerable dryness of air and subsoil. The capacity of the air of any locality to take up moisture depends on the temperature, the relative humidity, the density, and the rapidity of air movement. It is increased by rise of temperature, dryness of the air, and by wind, while it is diminished by lowering of the temperature, absence of sun, stillness of the air, and high degrees of relative humidity.

Atmospheric moisture is the great regulator of the distribution of the heat over the surface of the earth. While it moderates in some degree the direct solar rays of heat and light, it acts still more powerfully by absorbing the radiant heat reflected from the surface; indeed, were it not for the watery vapour present in the air, the whole surface of the earth would become frozen in a single night. Even the dew, which is formed by nocturnal refrigeration, becomes an additional protection in preventing the earth's heat from radiating into space.

What is called the *dew-point* is the temperature at which the air is so completely saturated with moisture that the least further fall causes condensation. If the dew-point be below the freezing-point, the moisture deposited will pass at once into the solid form and appear as hoar-frost. This, however, is not frozen dew, but moisture deposited in the solid form. Clouds, by reflecting back the heat radiated from the earth, prevent the deposition of dew, nor can dew be deposited when there is much wind, because the air cannot remain long enough in contact with the surface for any material reduction of temperature, and consequent condensation, to take place.

Clouds are formed by the condensation of vapour in a stratum of air at a considerable height, and are constantly disappearing to be re-formed. The warm air charged with moisture rises, is condensed, forms a cloud, and begins to fall, but coming in contact with another warm layer of

air, the moisture which it contains is vaporised to a certain extent and the cloud changes in form or disappears. The curious phenomenon of a cloud clinging to the side of a mountain, when a strong wind is blowing, is explained by the fact that it is as quickly formed as it is blown away. A mist is merely a cloud near the surface of the ground, and is distinguished from a fog by the particles of moisture being somewhat larger. Fogs are generally caused by the intermixture of masses of air of varying temperatures, by warm currents of moist air flowing over cold surfaces, or by cold air flowing down into a warm and damp atmosphere. The condensed moisture constituting a fog has a tendency to deposit itself on foreign particles floating in the air, and accordingly London fogs are pre-eminently opaque owing to the enormous amount of carbon, in the form of soot, which the atmosphere holds in suspension.

5. *Light and Electricity.*—The relations of these two factors in their effects on climate are so closely allied with conditions of temperature that they do not admit of strict differentiation. There is no doubt, however, that they both exercise important influences on organic function, and are intimately connected with what are known as bracing or relaxing conditions. The observations made at the Kew Observatory tend to show that the atmosphere always contains free electricity, which is positive in far the greater majority of instances at about 5 feet above the surface of the ground, but is generally negative close to the surface. Although both positive and negative electricity can be detected in the air of dwellings, the former is soon used up if efficient ventilation is impeded.

Section II.—Meteorological Observations and Instruments

The principal meteorological observations which are systematically recorded at numerous stations throughout the country include atmospheric pressure, temperature,

humidity, rainfall, force and direction of winds, and the indications presented by clouds.

1. *Atmospheric Pressure.*—Although there is a great variety of barometers designed for common use, the instrument as usually constructed for scientific observation purposes consists of a glass tube about 34 inches in length, closed at one end, filled with mercury, and placed vertically with the open end dipping into a cup containing mercury. This type of barometer is known as the *cistern* barometer. Another type, namely, the *syphon* barometer, consists of a tube bent in the form of a syphon, having the same diameter at the lower as at the upper end, and though in many respects it is a more perfect instrument than the cistern barometer, it presents the great disadvantage of necessitating two readings, one for each arm of the syphon. A modification of the syphon barometer, familiar in many houses, is known as the *wheel* barometer, but this has little to recommend it as a trustworthy instrument. The *aneroid* barometer, on the other hand, is simply an air-tight circular metallic box from which the air has been nearly exhausted. The elastic sides of the box, which are kept apart by a delicate spring, are acted upon by the varying pressure of the atmosphere, and the resulting movements are conveyed by levers to an index which moves on a circular graduated scale.

What is called the standard land barometer, known as Fortin's *cistern* barometer, is the instrument recommended for accurate scientific observations. The special feature of this instrument consists in a pliable leather base to the cistern, which can be lowered or raised by means of an adjusting screw, so that the surface of the mercury in the cistern can always be accurately adjusted to the same level, or what is called zero-point, when the readings are taken. A small ivory pin, the point of which represents the zero-point of the tube, is fixed to the upper frame of the cistern, and when an observation is taken, the surface of the mercury is made to coincide with the point of the pin as the standard level from which the barometric column is to be measured.

The cistern, or upper part of it, is made of glass, in order that the ivory pin and the surface of the mercury may be visible, and the tube itself is enclosed in a brass case, on the upper part of which the scale is measured. Unless the instrument is required for use at great heights, the scale is only divided on the parts usually required, viz. from 27 to 32 inches, and each inch is divided into tenths and half-tenths, or 0·100 and 0·050 of an inch.

In order to increase the accuracy of the readings, there is attached to the scale of every standard barometer a small movable scale, worked by a rack and pinion, called a "Vernier," from the name of its inventor. This is divided into twenty-five spaces which correspond with twenty-four spaces on the fixed scale, and as each space on the fixed scale is 0·05 inch, it is larger than a space on the vernier by the twenty-fifth part of 0·05 inch, or 0·002 inch, so that the vernier shows differences of two-thousandths of an inch.

Another necessary adjunct of the instrument is the attached thermometer, the bulb of which should either be close to the tube or should enter the cistern. Great care should be taken with respect to the position of the instrument. It should always be fixed in a good light, but out of the reach of sunshine, and as far as possible from the direct heat of a fire or lamp. It should hang absolutely vertically, and at such a height that the eye of the observer should be as near as possible on a level with the top of the mercury.

In making an observation there are three points which should be remembered, and they should be attended to in the order in which they are mentioned. First, take the reading of the attached thermometer; next, adjust the mercury in the cistern by means of the thumb-screw, so that it exactly touches the point of the ivory pin, which, with its reflection on the surface of the mercury, will then appear as a double cone; and lastly, adjust the vernier so that its lower horizontal edge forms a tangent to the convex curve of the top of the mercurial column. The exact height of the column is then read as follows:—

Suppose after adjustment that the zero or lower edge of the vernier and the scale occupy the relative positions illustrated in Fig. 6, then it is seen first that the zero of the vernier is on a level with the part of the scale between 29·15 and 29·2 inches, so 29·15 is noted as the first part of the reading. On examining the subdivisions of tenths on the scale and on the vernier, it is next seen that the line on the vernier which forms a straight line with a line on the scale is the second line above 3, namely ·034, and this when added to the scale reading makes 29·15 + ·034, or 29·184 inches, which is called the observed reading.

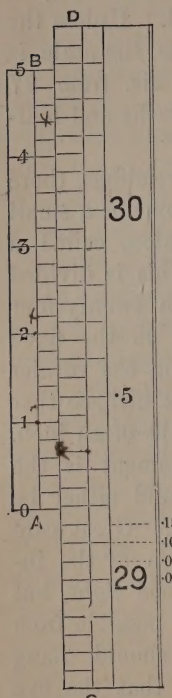


Fig. 6.—A B, Vernier; C D, part of fixed scale of Barometer.

For scientific purposes of comparison it is necessary that certain corrections should be applied to all barometric readings in order to bring the indications of different instruments in harmony with each other, namely, those for (1) index error, (2) capacity, and (3) capillarity, furnished by the certificate of the Kew Observatory which accompanies every good instrument; (4) the correction for height above mean sea level; and (5) the correction for temperature. All readings are reduced to 32° Fahr., and tables are given in Scott's *Instructions* and other publications, by the help of which the corrections for temperature and altitude can readily be made. The following example from Scott's *Instructions* will show how these corrections are applied:—

Suppose that—	
Barometer reading	= 29·946 ins.
Attached thermometer	68°
Kew correction for instrument	= + ·014 in.
Temperature of air by dry bulb	= 50°
Altitude of cistern above the mean sea level	= 105 ft.

Then we have—	
Uncorrected reading	= 29·946 ins.
Add for Kew correction	+ ·014
Reading . . .	29·960
Deduct temp. correction for 68° and 30·0 ins.	− ·106
Reading at 32° F.	= 29·854
Add for altitude of 105 ft. at temp. of air 50° and *approximate* pressure at sea level 30·0 ins.	+ ·116
Reading corrected and reduced to 32° F. at mean sea level	= 29·970 ins.

2. *Temperature.*—The thermometers used in meteorological observations are of various kinds, but all of them consist of a long glass tube of very small bore, closed at one end, and blown out at the other into a bulb or reservoir, which is filled with mercury or some other liquid. The temperature is indicated by the expansion or contraction of this liquid, and is measured by the length of the thread of liquid which extends from the bulb into the tube. The three principal thermometer scales are the *Fahrenheit*, used in this country and America; the *Centigrade*, now generally used on the Continent; and the *Reaumur*, formerly much used in Germany. The freezing-point, or point at which ice melts, is marked on the Fahrenheit scale at 32°, and at 0° in both the centigrade and the Reaumur scales, while the point at which water boils at 29·905 barometer pressure is marked at 212° on the Fahrenheit, 100° on the centigrade, and 80° on the Reaumur. The degrees, therefore, into which these scales are respectively divided between these two points are 180, 100, and 80; and hence the formula of reduction from any one scale to either of the other two is:—

$$\frac{F-32}{9}=\frac{C}{5}=\frac{R}{4}$$

In the two last, any degree of temperature below freezing-point is represented by a *minus* sign, while in the Fahrenheit scale the minus sign is only used for temperatures lower than 32° below freezing-point.

All thermometers used for scientific purposes should be thoroughly tested, and be accompanied by a Kew certificate. The instruments which are generally used are the following —(1) the dry bulb thermometer of a Mason's hygrometer, which will be subsequently described, furnishes the temperature of the air in the shade; (2) a maximum self-registering thermometer for indicating the highest temperature of the air reached in the shade; and (3) a self-registering minimum thermometer for registering the lowest temperature of the air in the shade.

In the *maximum* thermometer the tube is slightly bent and contracted close to the bulb in such a way that, while the expansion of the mercury is sufficient to force the liquid past the obstruction, it is not drawn back again when the temperature falls. It therefore remains broken, as it were, at the point of contraction, so that the thread of mercury left in the tube represents the precise amount forced past the contraction when the temperature was highest, and the maximum reading is taken at the end of the thread.

In order to set this thermometer, it should be held bulb downwards, and shaken, when the thread of mercury will return and become continuous with the mercury in the bulb, and it will then indicate the same temperature as that of the air. The instrument should be hung at an angle slightly differing from the horizontal, with the end of the tube downwards.

The *minimum* thermometer generally used is an alcoholic thermometer with a small metallic index which moves with little difficulty in the tube. It is set by sloping the instrument with the bulb uppermost, and thus allowing the index to slide nearly to the end of the spirit; and when so set, it should be placed in a nearly horizontal position. As the spirit contracts during cold, it carries the index with it back towards the bulb, and when it expands again, the spirit flows

past without moving it, and thus leaves it at the degree of greatest cold. The reading is taken at the end of the index farthest from the bulb.

Both these instruments should be placed in a screen standing four feet above the level of the ground, but not under the shadow of any trees, nor within twenty feet of any wall. The stand recommended is that of the Meteorological Society, the screen of which is so constructed that while it admits of free ventilation, it protects from sunlight and wet.

The *sun maximum*, or *solar radiation, thermometer*, consists of a glass case from which the air has been exhausted, and containing a mercurial thermometer with a blackened bulb which absorbs the sun's rays. The thermometer resembles the *shade maximum* thermometer already described, and is set, hung, and read in the same way. It should be freely exposed to sun and air on a stand about four feet from the ground, at a distance from walls or trees, and with the bulb directed to the south-east. The greatest amount of radiation which has occurred during the day is indicated approximately by the difference between the maximum temperature of the air in the shade and the maximum temperature registered by the solar radiation thermometer. The *minimum*, or *terrestrial radiation thermometer*, resembles the ordinary minimum thermometer, but is protected by a glass shield. It is exposed on grass, which should be kept closely cut, or on a black board close to the ground. The difference between the minimum temperature so registered and the minimum in the air is taken as the amount of terrestrial radiation.

In recording temperature, the dry bulb of the *dry and wet bulb* thermometer is read as a common thermometer. The approximate mean daily temperature may be obtained by taking observations at certain times during the day and applying Glaisher's corrections. For example, if the temperature be taken at 7 A.M., 2 P.M., and 9 P.M., and t, t', t'', denote the temperature at these hours respectively, then the mean temperature of the day will be $\frac{t+t'+2t''}{4}$; or if the

hours be 8 A.M., 3 P.M., and 10 P.M., the formula is $\frac{7t+7t'+10t''}{24}$. In many places the *mean temperature* of the day and year is derived solely from the mean of the shade maximum and minimum, and this approximates nearly to the truth. At Greenwich and other observatories, where the height of the thermometer is registered by photography at every moment of the day, the mean of the hourly readings is taken. Or if the temperature be taken twice a day at homonymous hours, such as 9 A.M. and 9 P.M., the mean of these observations do not differ much from the true daily mean (Scott). The *mean daily range* of temperature is obtained by deducting the average daily maxima from the average daily minima temperatures. The *extreme daily range* in the month or year is the difference between the maximum and minimum thermometer on any one day. The *extreme monthly* or *annual range* is the difference between the greatest and lowest recorded temperatures in the month or year. The *mean monthly range* is the sum of the daily ranges divided by the number of days in a month, while the mean annual range is the sum of the monthly ranges divided by 12.

On land the lowest temperature is about 3 A.M. or just before sunrise, and the highest about 2 P.M. The extreme daily range is greater on land than on water, in the interior of continents than by the sea-side, and in elevated regions than at sea level. The annual range is also greater on land, and is highest in the interior of great extra-tropical continents.

The temperature of any locality, as has already been explained, is influenced by geographical position, by the relative amount of land and water, by elevation above sea level, by aspect and exposure, and by the nature of the soil and the amount of vegetation. So far as surface is concerned, the best reflectors are the worst absorbers of heat. The nearer the colour of the ground approaches to white, the greater will be the sun warmth and the cooler the air; while the darker the colour, the warmer will be the air, and the less will the heat of solar radiation be felt. The

temperature, too, is greatly influenced by the amount of moisture contained in the soil. Moist and clayey soils are cold because the heat is absorbed by evaporation, while dry hard rocks and dry sands and gravels are warm. According to Buchan, the mean temperature of arable land is raised nearly 1° Fahr. by drainage, and the temperature is rendered much more equable. Hence it is, as shown by the researches of Buchanan and Bowditch, that drainage exercises such an important influence on the diminution of phthisis. As regards the influence of vegetation, it may be said generally that while this covering prevents the soil from being heated to the same degree as dry sand or bare rock, the air itself is cooled by the process of evaporation which is constantly going on from the foliage. Peat and marsh lands are specially characterised by a low annual temperature, and their surfaces are often covered with mists.

Lines drawn on charts connecting places with the same mean annual temperature, as first proposed by Humboldt, are called *isothermal lines*. If there were no causes leading to deviations, these lines would be parallel to the equator, but as shown on a map they exhibit wide fluctuations, curving towards the north in some regions and towards the south in others. They further show that north of the equator there is a great difference between the course of the winter, the summer, and the annual isothermals. The winter isothermals rise considerably in a northerly direction in the northern Atlantic, in the British Isles, and the west coast of Norway, and descend or curve towards the equator in the interior of the continents of Asia and America, while the summer isothermals exhibit an opposite course. In the southern hemisphere the isothermals do not manifest such wide fluctuations, on account of the much greater proportion of water to land, and with increasing distances from the equator they become almost parallel.

3. *Humidity.*—The amount of watery vapour or the hygrometricity of the air may be determined by hygrometers such as Daniell's and Regnault's, but the instrument generally used in this country is known as Mason's *dry*

and *wet bulb thermometer*, which really consists of two thermometers, both bulbs of which project below the scales. At meteorological stations the instrument is usually placed in the same screen as the maximum and minimum thermometer, and therefore under the same relative conditions as to height from ground, etc. The wet bulb is covered with muslin, over which there is twisted a small skein of lamp cotton which dips into a little vessel containing either rain water or distilled water. The cotton should be boiled in ether or soaked in a solution of sodium carbonate, to free it from fat, so that the water may readily ascend by the force of capillary attraction and keep the bulb moist. The muslin and cotton should be renewed once or twice a month, and care should be taken to regulate the supply of water in the little reservoir. This should be placed at some distance on the off side of the wet thermometer and as far as possible from the dry. When the temperature of the air is below the freezing-point, the passage of water along the cotton is arrested, and it is then necessary to moisten the wet bulb with cold water some time before the hour of observation so as to allow the moisture to freeze.

The principle of action of this hygrometer depends upon the fact that so long as the atmosphere is not saturated with moisture, evaporation will take place on any free surface, such as the moist covering of the wet bulb, and heat is abstracted. If, however, the air is saturated, no evaporation is possible, and the two thermometers, the dry and the wet bulb, will read alike, and the temperature then noted is the *dew-point*. Occasionally, as in a thick fog, or during cold, calm weather, the wet bulb may read slightly higher than the dry bulb, and when this occurs, the reading of the dry bulb, according to Scott, should be taken and considered as the point of saturation. The dew-point, then, is the temperature of the air when it is so saturated with moisture that the least cooling will cause condensation or deposit of water. If the dry and wet bulbs are not of the same temperature, the dew-point is always more or less lower than the temperature of the wet bulb, and it can be calculated conveniently by

Glaisher's table of factors, from which the following are selected as examples :—

Reading of Dry-bulb Therm.	Factor.	Reading of Dry-bulb Therm.	Factor.
50°	2·06	70°	1·77
51°	2·04	71°	1·76
52°	2·02	72°	1·75
etc.	etc.	etc.	etc.

The rule of calculation is to take the difference between the dry and wet bulb, and multiply it by the factor which stands opposite the dry bulb temperature, then deduct the product from the dry bulb temperature, and the result is the dew-point.

The dew-point having been ascertained, the weight of a cubic foot of vapour, and the amount of *vapour tension*, or *the absolute humidity*, can also be ascertained from tables.

As has already been explained, the *relative humidity* is merely a convenient term to express dryness or moisture of the air. Complete saturation being assumed to be 100, the relative humidity is expressed by the proportion of vapour actually contained in the air to the amount which it could contain when fully saturated. The relative humidity corresponding to different temperatures of the dry and wet bulb, as well as the weight of a cubic foot of dry air, or of dry and moist air, are all given in Glaisher's Hygrometrical Tables.

A modification of what is called the Saussure's hair hygrometer is generally used in Norway and Russia, and is recommended where extreme severity of climate is met with. It consists of a human hair freed from fat by steeping it in ether or a solution of liquor potassæ, one end of which is fixed, and the other is attached to a small needle, and according as the hair becomes shorter or elongates, the needle traverses a graduated scale, and thus indicates the relative humidity. After a time, however, it loses its delicacy, and requires to be readjusted.

4. *Rainfall.*—The amount of rainfall is measured by a rain gauge, containing a circular collecting funnel fitted with a vertical rim about six inches deep, and a can in which the rain is caught. The diameter of the rim of the funnel recommended by the Meteorological Department is eight inches. The gauge should be fixed firmly into the ground by means of four short stakes, and the top of the rim should be about twelve inches above the surface. It should be set up in a well-exposed position, and as far from a neighbouring object, as a wall or tree, as that object is high.

At stated times (usually at 9 A.M.) the top is taken off, and the can emptied into a glass vessel graduated to hundredths of an inch, which accompanies the gauge. When snow has fallen it should be melted before it is measured; or if the fall is deep, an approximate estimate may be obtained by measuring the depth of snow in inches, and taking one-twelfth as representing the rainfall. The fall of an inch of rain implies that over a given area rain has fallen to the depth of one inch. The average mean annual rainfall of England and Wales is estimated to be about 25 inches, and every inch of rain falling on an acre of space represents 22,622 gallons of water. (See Appendix.)

5. *Winds.*—The direction of the wind is determined by vanes, or may be ascertained by observing the lower stratum of clouds. The velocity can be approximately estimated by Robinson's anemometer, which consists of four small cups fixed at the ends of horizontal axes of such a length that 500 revolutions indicate one mile. By means of clockwork and a dial the number of miles traversed by the wind in a given time can thus be roughly determined. Osler's anemometer, which is much more complicated, registers on a piece of paper fitted on a drum, the direction, velocity, and pressure. The velocity is reckoned as so many miles per hour, and the force as so many pounds, or parts of a pound, on a square inch of surface. If the velocity is known, the pressure per square foot can be ascertained by multiplying the square of the velocity per hour by ·005, or $V^2 = 200\ P$

In this country, the average velocity of the wind near the surface of the earth is from 6 to 8 miles an hour. In heavy winds it rarely exceeds 45 miles, or in a hurricane 80 miles an hour. The following table from Buchan's *Meteorology* gives a fairly approximate estimation of the velocity of the wind in relation to force and pressure :—

Estimated Force.	Pressure in lbs. per sq. ft.	Velocity in miles per hour.	Popular Designation.	Estimated Force.	Pressure in lbs. per sq. ft.	Velocity in miles per hour.	Popular Designation.
0·0	0·00	0·0	Calm.	3·0	9·00	42·4	Very fresh.
0·1	0·01	1·4	Lightest breath of air.	3·5	12·25	49·5	
0·5	0·25	7·1	Very light air.	4·0	16·00	56·6	Blowing hard.
1·0	1·00	14·1	Light air.	4·5	20·25	63·6	
1·5	2·25	21·2	Light breeze.	5·0	25·00	70·7	Blowing a gale.
2·0	4·00	28·3	Fresh ,,	5·5	30·25	77·8	Violent gale.
2·5	6·25	35·4		6·0	36·00	84·8	Hurricane.

6. *Clouds.* — Clouds, as recognised by meteorologists, have been classified into three primary, and four compound, types. The primary types are the *cirrus*, the *stratus*, and the *cumulus*. The *cirrus*, or mare's-tail cloud, is a streaky cloud, like a feather or spray, which appears at a very great height in the atmosphere, and is generally regarded as a sign of wind. The *stratus* is a sheet or layer of cloud, usually of uniform thickness, and belongs essentially to the lower regions of the atmosphere. It is generally a fine weather cloud, appearing during the evenings and mornings of the brightest days. All low detached clouds which look like lifted fog, and present little variety of light, shade, or definite form, belong to this type.

The *cumulus* is a very common form of cloud, and consists of rounded masses resting on a horizontal base. It is produced by an ascending current of air, the vapour of which is rapidly condensed, and has a tendency to collect in rudely globular masses, like the steam escaping from a locomotive on a frosty day.

The compound types are the *cirro-stratus*, the *cirro-cumulus*, the *cumulo-stratus*, and the *cumulo-cirro-stratus* or *nimbus*. The *cirro-stratus* is usually generated by increased condensation in the *cirrus*, which consequently sinks to a lower level, and is generally the precursor of bad weather. The *cirro-cumulus* presents the appearance of small detached rounded masses of cloud, and forms the well-known "mackerel sky." The *cumulo-stratus* is generally dark and flat at its base and traversed by horizontal lines of dark cloud. It is a variation of the *cumulus* changing into the *nimbus*, or *cumulo-cirro-stratus*, familiarly known as the rain cloud. Indeed, the *nimbus*, whilst on the horizon, or as it advances towards the observer, frequently presents the appearance of a very heavy *cumulo-stratus* fringed with falling rain and with some *cirrus* above. When it has covered the whole sky, it is so concealed by falling rain that it generally assumes a uniform dark appearance.

But in addition to the form of clouds, it is equally important to observe their course of motion. Generally speaking, the clouds of the lower stratum of air move in the same direction as the wind on the surface, except in mountainous districts, where winds are affected by local eddies. But at all times even the lowest clouds move far more rapidly than the winds near the surface of the ground. As regards the upper clouds, however, the case is very different, for they generally move in a direction different to the course of the wind on the surface; and by studying their motion much light has been thrown on the currents of air in the upper regions. There are good grounds for believing that these upper clouds are frequently composed of particles of ice. The lower clouds, on the other hand, namely, the *stratus*, *cumulus*, *cumulo-stratus*, and *nimbus*, are usually composed of condensed vapour.

In estimating the amount of cloud, a system of numbers is adopted from 0 to 10, 0 expressing a cloudless sky and 10 a sky completely overcast. The proportionate amount of cloud observed is recorded by intervening numbers, but without any reference to the thickness of cloud.

7. *Electricity.* — The various modes of testing the amount and kind of electricity present in the air also leave much scope for further research, and hitherto have led to little practical result. All that is expected of the ordinary meteorological observer is to note the occurrence of lightning and thunderstorms. For estimating the density of electricity existing in the air under ordinary circumstances, and whether it is positive or negative, the instrument which is now generally used is Thomson's Electrometer (see Scott's *Meteorology*).

8. *Hours of Observation.*—For volunteer observers the combination of 9 A.M. and 9 P.M. has been selected as the most suitable for recording observations throughout the United Kingdom, and the average of the readings of the maximum and minimum thermometers at these hours may be taken as approximating very closely to the true daily mean. (See *Official Instructions* prepared by R. H. Scott, F.R.S., Director of the Meteorological Office.)

Section III.—Weather Forecasting

Before the electric telegraph came into operation, barometric readings were only of value in the localities in which they were taken, but for years back a system has been adopted under which simultaneous readings, at any given time, can be obtained at different stations distributed over a very wide area, embracing the United Kingdom and other parts of Western Europe. These readings are recorded on a map, and if lines be drawn connecting the localities where the same pressure prevails, what is called a "synoptic chart" is sketched which is made of lines of equal barometric pressure, or "isobars," as they are termed. Extended observation has shown that these isobars generally arrange themselves into certain typical forms, known as "cyclones," "secondary cyclones," "anti-cyclones," "V-shaped depressions," "wedges of high pressure," "cols or necks," and "straight isobars" (Fig. 7).

The closeness of the isobars, or the rapidity of changes of pressure, indicate the "barometric gradient," to which the velocity of the wind is proportionate,—the velocity being greatest at the localities of steepest gradient, and *vice versa*.

(1) *Cyclones.*—As represented on a synoptic chart, cyclones are formed by concentric isobars, the outer lines marking a higher pressure than the inner, while the lowest pressure is at the centre. If the amount of depression in the centre is great, then the isobars are generally close together, and the gradient is said to be steep.

(2) *Secondary Cyclones* are areas of low pressure formed by looped or incomplete concentric isobars, having likewise the lowest pressure towards the centre. They frequently follow primary cyclones.

(3) *Anti-cyclones.*—These are represented by more or less

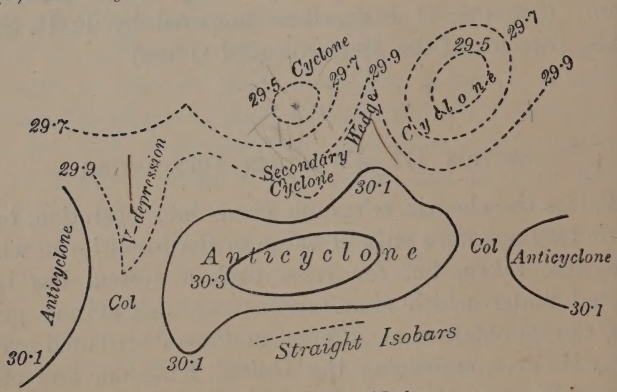


FIG. 7.—Typical Forms of Isobars.
(After ABERCROMBIE.)

concentric isobars, but with the highest pressure in the centre. The barometric gradients are slight.

(4) *V-Shaped Depressions* frequently form the angular intervals between adjoining anti-cyclones, with the lowest pressure in the interior. In the northern hemisphere, the tip is generally directed southwards.

(5) *Wedges of High Pressure* usually point to the north, and move along between two adjoining cyclones. They

are never stationary, and are commonly followed by well-defined cyclonic areas.

(6) *Cols or Necks* are areas of comparatively low pressure, lying between two anti-cyclonic areas.

(7) *Straight Isobars* are without any marked curve, and do not enclose any area of either high or low pressure. Like cols, they indicate an intermediate arrangement of the atmospheric circulation which precedes the formation of a cyclone.

In order to restore atmospheric equilibrium, the air always tends to move from a region where the barometer is high and the pressure greatest, towards one where the barometer is low and the pressure least. Hence currents of air set in from all sides towards the centre of a cyclonic area, and flow out in all directions from the centre of an anti-cyclonic area. But owing to the rotatory influence of the earth already described, these air-currents do not flow straight to or from the centre of cyclonic or anti-cyclonic systems, but are deflected in the direction of the isobars. In other words, the wind crosses the isobars obliquely, and may be said to blow spirally into a cyclone, and spirally out of a cyclone. But whatever the arrangement of the isobars may be, the relation of the wind to pressure is always correctly indicated by "Buys Ballot's Law"; if a person stands with the high barometer to his right hand, and the low to his left, the wind will blow on his back. The grouping of the isobars in a synoptic chart therefore indicates the direction of the wind, just as the distances between them, or gradients, indicate its strength.

Cyclones, secondary cyclones, V-shaped depressions, and wedges generally travel in an easterly direction, and, in Western Europe, at the rate of about twenty or thirty miles an hour. In America, however, they commonly travel as fast as fifty miles an hour. On the other hand, anti-cyclones differ from all other forms of isobars in tending to remain stationary, and also to extend over very wide areas.

In respect to weather features, the front of an advancing cyclone is always associated with stratiform clouds, moist

atmosphere, a dirty gloomy sky, and often a drizzling rain, which gradually changes into a driving rain accompanied by squalls of wind in the trough or centre of depression. As the rear of the cyclone moves onward, the rain moderates into showers, followed by a brighter sky, a brisker air, cumulus clouds and sunshine. Secondary cyclones and V-shaped depressions are accompanied by similar weather changes. The weather features associated with anti-cyclonic conditions are exactly the opposite of these. In front of them and at the centre are blue sky, dry air, sunshine, little or no wind, and a hazy horizon. Wedges, like anti-cyclones, are very usually associated with fine weather, especially towards their base, but towards the thin end, with showers or thunderstorms. Over cols or necks, the weather is generally stagnant and gloomy, and in summer "thundry," while straight isobars are too transitional to be characteristic of any particular weather features, though they are often associated with a hard sky, a blustering wind, and an inclination to rain when the wind falls.

Although these various forms of isobars are liable to merge into other forms at any time, it is often possible to "forecast" the weather by studying synoptic charts, such as those issued by the Meteorological Office in London, and especially when advantage is taken of the Transatlantic observations which are telegraphed to this side, inasmuch as most cyclonic disturbances move from west to east. Weather forecasting, therefore, will be rendered all the more reliable in those countries which lie eastwards of neighbouring areas provided with meteorological stations. For example, Norway and Germany are better situated in this respect than either France or England, and England than Scotland, on account of the westerly outposts afforded by Ireland. The difficulties of weather prognostication in this country are increased owing to its geographical position, which precludes any early knowledge of the formation of cyclonic disturbances in the Atlantic.

Section IV.—Climate and Weather Changes in Relation to Health

1. *Climate.*—Although there can be no question that the human organism possesses wonderful powers of adaptability to extremes of climatic conditions, it is equally true that the various races of mankind have their prescribed salubrious limits. Thus, it is found that the white races attain their highest degree of physical development and the greatest average duration of life above 40° of latitude in the western, and 45° in the eastern, hemispheres, and whenever they emigrate to regions many degrees below these lines they begin to deteriorate, owing to the increased temperature and to other conditions which are more or less dependent upon excessive heat. For the effects of a tropical climate are to a large extent relative, inasmuch as the temperature and humidity of the air are highly favourable to putrefactive change, and tend to intensify those pollutions of air and water which are so inimicable to health in all climates. Then, again, there can be little doubt that much of the ill-health from which Europeans suffer in tropical climates is largely due to errors in diet, and particularly to over-indulgence in alcoholic drinks, and to the eating of too much animal food.

When the temperature of the air approaches, or even exceeds, as it sometimes does, the temperature of the blood, metabolism is diminished, because there is little call made upon the heat-producing powers of the body, and therefore less food is required. The amount of urine and the amount of urea in the urine are both lessened, as well as the amount of carbonic acid exhaled from the lungs, while the oxygenation of the blood is diminished owing to the lessened number of respirations. On the other hand, the skin acts much more vigorously than usual, and in newcomers, the consequent local hyperæmia often becomes painfully manifest in the eruption familiarly known as "prickly heat." After a time, however, the skin becomes altered in structure and yellowish in colour, owing to the deposition of pigment

in the deeper layers of the cuticle. Apart altogether from malarial or other unwholesome conditions, it may be said generally that the continued effects of residence in a tropical climate result in sluggishness of body and mind, enfeeblement of health, the premature advance of old age, and a shortening of the average duration of life.

The most enervating effects of heat are experienced when the heat is continuous, and when it is combined with great humidity of the atmosphere. A shade heat of 90° to 100° is very overpowering, and the same persons who could sustain prolonged hard work in a sun heat of 110° to 120° would speedily become exhausted in a shade heat of 95°. Then, too, a much greater degree of heat can be borne when the air is in movement than when it is perfectly still, and it is certain that sunstroke rarely occurs in high elevations or in mid-ocean, where the sun heat is often excessive.

With regard to the effects of living in a cold climate, there can be no doubt that with a sufficiency of food and warm clothing, healthy persons can withstand even the extreme asperities of the Arctic regions. But to maintain the temperature of the body, tissue change must be rapid; more food, and especially carbonaceous food, must be taken; the circulation and respiratory movements are quickened; and the mental and bodily vigour appear to be increased. People from this country who emigrate to colder regions, such as Canada and Nova Scotia, not only enjoy good health, but produce a progeny perhaps even more vigorous than the parent stock, owing to the active out-door lives which they lead. On the other hand, there is a general consensus of opinion that they do not flourish in climates with an average temperature of 20° higher than their own, and that the race dwindles and finally dies out.

Although atmospheric moisture exercises important influences on bodily function, it is very difficult to estimate these influences apart from those depending on temperature, atmospheric pressure, movement of air, and other conditions. Great humidity of the air impedes the evaporation from the skin and lungs, and when this is associated with a high

temperature, the cooling of the body is so much interfered with that there is very often a slight increase in the blood temperature. Hence it is that the moist siroccos, which are almost saturated with watery vapour, become so oppressive to man and beast. In dry warm air, when the heat is not excessive, the skin parts with much moisture; in dry cold air, on the other hand, the loss by evaporation, through the lungs, is greatly increased. In temperate climates, the most agreeable degree of humidity for healthy persons is about 75 per cent of saturation. Invalids suffering from chronic lung diseases, such as bronchitis, emphysema, and some forms of phthisis, prefer a warm, equable, and moist climate, because a dry atmosphere causes cough and irritation, no doubt owing to the increased evaporation thrown on the lungs.

Atmospheric moisture has a further important bearing on public health, inasmuch as it is a most potent factor in the spread of malarial and filth diseases. A dry atmosphere checks putrefactive change, while a warm moist atmosphere greatly increases it; hence it is that summer diarrhœa in temperate climates often shows no unusual increase, even during very hot weather, if the degree of humidity remains comparatively low. If, however, the weather continues warm and the air moist, summer diarrhœa is certain to become more prevalent.

The climate of islands and of localities near the seashore differs from that of the interior of continents in being much more equable, not only as regards seasonal variations, but in respect to the variations of temperature between day and night. Hence has arisen the subdivision of climates into insular or moderate, and continental or excessive.

Then, again, climate is largely influenced by altitude. The climate of hill stations in tropical countries is rendered enjoyable and salubrious compared with that of the plains owing to the reduction of temperature, combined with other conditions, such as greater movement of the air, greater purity, more sunlight, greater dryness, and an increased amount of ozone. Although the weight of oxygen in a

cubic foot of air is decreased in high altitudes, the oxygenation of the blood is increased, because the respirations become more frequent and are of greater depth. The action of the heart is also increased, and tissue change is stimulated, leading to increased bodily activity. These beneficial effects of residence at high altitudes have led to the treatment of phthisis at mountain resorts, and with marked success in the earlier stages of the disease. Other diseases which are greatly benefited by mountain air are anæmia, gout, rheumatism, impaired digestion, and neuralgia.

When the climate of particular stations is considered, it is generally found that it is regulated mainly by the influence of the wind. A station which is sheltered from cold winds by a range of hills, a cliff, or even a belt of trees, and is open to warm winds and possesses a southern aspect, presents favourable conditions as a winter health resort. Easterly winds in this country are very trying to healthy persons, and often very fatal to the old and young; when dry, they act injuriously by causing rapid evaporation of moisture from the skin and lungs and diminishing the bodily heat; and when cold and moist, the bodily heat is abstracted from the skin and lungs by conduction and not by increased evaporation. It is on this account that a combination of great cold and fog is felt so keenly.

2. *Weather Changes.*—Cold is the most common cause of disease in the fickle climate of this country. Even a momentary exposure to a cold draught of air is as frequent an excitant of disease as general exposure for a long time. At least one half the number of patients who apply for treatment at our hospitals and public dispensaries during the winter months are afflicted with colds, coughs, and bronchial or rheumatic affections. The prevalence of diseases of the respiratory organs at this season, though due in great measure to the lowered temperature, is no doubt also partly attributable to the excessive moisture of the air, and when this is associated with low barometric pressure conditions inimical to health are still further intensified. But apart from any effects due to temperature, it has long

been a popular belief that old wounds, diseased bones, and rheumatic joints are very sensitive, and often become painful on the approach of a storm, which in this country would be indicated by a sudden lowering of the barometric column by at least half an inch. This is explained by the fact that the principal effect of diminished atmospheric pressure is distension of the capillaries.

As regards seasonal influence, the researches of the late Edward Smith possess an important bearing. He found, for example, that the activity of the vital processes varied in a very definite manner,—the maximum being in spring, the decline and minimum in the summer, the minimum and the increase in the autumn, and a stationary elevation in the winter. Even with the same amount of exertion, less carbonic acid is apparently evolved in summer than in winter.

Mild winters and cold summers both lower the mortality; while, on the other hand, a rise of mean temperature in the summer, or a fall in winter, is followed by an increased amount of sickness and a high mortality.

As regards seasonal influence on total mortality, it may be laid down as a rule that the general death-rate is highest in the first quarter of the year and lowest in the third—the order from highest to lowest being first, fourth, second, third, but in many districts this sequence is found to vary considerably, and occasionally varies in respect to the country generally.

CHAPTER VII

WATER

Section I.—Sources

All supplies of fresh water are derived from the condensation of the aqueous vapour contained in the atmosphere. Whether this falls to the earth in the form of rain or snow, a certain portion of it runs off the surface and gravitates towards the sea; another portion sinks into the soil, and, passing through strata which are more or less porous, or through fissures in rocks, again reappears in springs and wells; a third portion is evaporated where it falls; and the remainder becomes absorbed in the chemical composition of minerals, or is utilised in the processes of growth and decay of animal and vegetable life.

The rainfall which flows on the surface collects in streams, lakes and rivers, according to the conformation of the ground, while the water flowing under ground oozes to the surface either imperceptibly or in springs, and eventually unites with the surface water in its accumulation in lakes, or in its onward progress towards the sea.

The immediate sources of water-supply may therefore be classified as rain-water, and water from springs, wells, rivers, or lakes.

1. *Rain-Water.*—Rain-water is highly aerated, and, when uncontaminated by the receiving surface or by air impurities, is healthy and pleasant. But frequently, according to the analyses of the Rivers Pollution Commissioners, it contains a large amount of organic matter, and in this

country is usually far less pure than water derived from deep wells and springs. This is not to be wondered at when we consider that the atmosphere in a thickly-populated country like Great Britain becomes the recipient of vast quantities of excremental dust and effluvia, of smoke particles, and the products of animal and vegetable decay. It is therefore seldom stored on premises except for washing purposes; but in many Continental localities it is collected in underground reservoirs, and constitutes almost the sole source of fresh-water supply to the inhabitants. It is usually collected from the roofs of houses, and occasionally from paved or cemented ground.

The amount of water derivable from the rainfall in given cases is readily ascertained, if the mean annual rainfall of the district is known, and the dimensions of the receiving area are obtained. Thus, when the roofs of houses constitute the receiving area, the transverse section of the buildings will be one factor, and the mean annual rainfall the other. If, instead of the roof-surface, a cemented piece of ground is the receiving area, the superficial area in square yards, multiplied by the rainfall in inches, and this again by 4·673, will give the total number of gallons, because one inch of rainfall delivers 4·673 gallons on every square yard. But in either case a large percentage must be allowed for evaporation and waste—in respect to roof surfaces about one-half, and other collecting areas about one-fourth of the average rainfall. The amount of storage capacity should be proportional to the roof area, and large enough to hold at least 4 inches rainfall. For domestic purposes, a filter should be provided, and a rain-water separator is also of advantage. (See Appendix.)

If lines be drawn through the sources of the tributaries of rivers marked on a map, they will be found to form the boundaries of certain areas which are called the catchment basins of the various rivers—that is, the areas which receive the rainfall supplying their waters. In compact formations, where most of the rain runs off the surface, the ridge lines bounding these basins usually pass along the most elevated

regions, but in porous formations their course will depend on the configuration of the retentive substratum.

The amount of rainfall which penetrates beneath the surface varies according to the density and configuration of the ground, and also depends on whatever influences the rate of evaporation. Thus, in loose sandy or gravelly districts, as much as 90 to 96 per cent sinks into the soil; in chalk districts, 42; in limestone, 20; while in districts of retentive impermeable clay the percentage is very small. Dr. Dalton, in his experiments on the new red sandstone soil of Manchester, found that 25 per cent of the whole rainfall penetrated to the depth of 3 feet; and Mr. Prestwich gave the amount of infiltration of the principal water-bearing strata surrounding London as varying from 48 to 60 per cent.

Other things being equal, the amount of infiltration will be far less in an undulating hilly district than in open level plains. It is obvious also that it must vary very considerably with the season of the year. Thus, according to the experiments of Mr. Dickinson, made in the gravelly loam which covers the chalk in the valleys around Watford, it was 70 per cent in the first three months of the year; in the summer months it was only 2; while in November and December, nearly the whole of the rainfall penetrated beneath the surface.

2. *Water from Wells, Springs, Rivers, and Lakes.*—The quality and composition of the water derived from these sources depend on the nature of the soil and geological strata through which it has passed, or on the character of its surface bed or channel. The rain, already charged with carbonic acid in its passage through the lower regions of the atmosphere, becomes, by the action of nitrifying micro-organisms, still more largely impregnated with this gas when it sinks beneath the surface. In some rich soils, the amount present in the air contained within their interstices, according to Boussingault, is 250 times greater than the ordinary atmospheric ratio. Aided by the action of the carbonic acid which it has thus absorbed, the rain-water dissolves and decomposes various chemical compounds which it meets with in its underground progress, and often becomes so

highly charged with them as to become unfit for ordinary use, as in the case of mineral waters.

(1) Surface or shallow-well waters, though sometimes comparatively pure, frequently contain a large amount of organic matter. In mossy moorland districts, for example, or in rich vegetable soils, the water may contain from 12 to 30 grains of vegetable matter per gallon, which imparts to it a yellowish or brownish tint; while in marshy districts the amount of organic matter varies from 10 to 100 grains. The saline constituents depend very much upon the geological character of the stratum in or upon which the well is sunk, but in inhabited places these are often masked by the products of excremental pollution. Shallow well waters are drawn from wells not more than 50 feet deep, and seldom exceeding half that depth. Surface waters from cultivated land are always more or less contaminated with manurial impurities, and should therefore be regarded as extremely suspicious waters.

(2) The water from deep wells and springs varies according to the geological strata through which it passes. Thus, alluvial waters are more or less impure, containing a large amount of salts (20 to 120 grains per gallon), and often much organic matter; while the chalk waters are clear, wholesome, and sparkling, holding in solution a considerable amount of calcium carbonate besides other salts, and being largely impregnated with carbonic acid. Also wholesome and agreeable to the taste, but not so suitable for cooking purposes, is the water from the limestone and magnesium limestone strata. It contains more calcium and magnesium sulphate than the chalk water, and consequently does not become so soft on boiling. Waters from the granitic, metamorphic, trap-rock, and clay-slate formations are generally very pure, and contain but small quantities of solids, consisting chiefly of sodium carbonate and chloride, with a little lime and magnesia. Waters from the millstone grit and hard oolite are also very pure. The saline constituents are by no means excessive, and are chiefly in the form of calcium and magnesium sulphate and carbonate,

with traces of iron. Soft sand-rock waters, loose sand and gravel waters, and waters from the lias clays, vary very much in quality and composition, some of them being very pure, as the Farnham waters, and others containing large amounts of mineral and organic matters.

(3) River water is in most cases softer than spring or well water. It contains a smaller amount of mineral salts, but is often largely impregnated with organic matter on account of the vegetable *débris* and animal excreta which find their way into it. Its constant movement, however, facilitates the oxidation of organic impurities, and this purifying process is largely aided by microbial action and plant-life.

(4) Lake water, especially in mountainous districts composed of the older rock formations, is generally very soft, containing little mineral matter; but as it is essentially a stagnant water, and as all lakes receive the washings of the districts in which they are situated, the amount of organic nitrogenous matter is sometimes very considerable. Any excess, however, of peaty matter in solution may be materially lessened by filtering through sand.

As regards the qualities of potable waters founded upon their respective sources, the following classifications are given by the Rivers Pollution Commissioners in their Sixth Report:—

a. In respect of wholesomeness, palatability, and general fitness for drinking and cooking:—

Wholesome.	1. Spring water.	Very palatable.
	2. Deep-well water.	
	3. Upland surface water.	Moderately palatable.
Suspicious.	4. Stored rain water.	
	5. Surface water from cultivated land.	Palatable.
Dangerous.	6. River water to which sewage gains access.	
	7. Shallow-well water.	

b. According to softness:—

1. Rain water.
2. Upland surface water.

3. Surface water from cultivated land.
4. River water.
5. Spring water.
6. Deep-well water.
7. Shallow-well water.

c. In respect to the influence of geological formation in rendering water sparkling, colourless, palatable, and wholesome, by percolation, the following water-bearing strata are given as the most efficient:—

1. Chalk.
2. Oolite.
3. Greensand.
4. Hastings sand.
5. New red and conglomerate sandstone.

Section II.—Quantity necessary for Health and other Purposes

A healthy adult requires daily from 70 to 100 oz. of water for the processes of nutrition, about one-third of which is contained in articles of diet, the other two-thirds being supplied in the form of liquids. The amount for cooking has been estimated at from half a gallon to a gallon daily for each person, while the quantity deemed necessary for personal cleanliness, and for washing purposes, will necessarily vary very much according to the habits of the individual.

Prof. Parkes estimated the following quantities to be used by a man in the middle class:—

	Gallons daily
Cooking	·75
Fluids as drink	·33
Ablution, including a daily sponge-bath	·5
Share of utensil and house washing	3
Share of clothes washing	3
	12·08

The soldier is allowed about 15 gallons daily, no extra allowance being given for the women and children in a regiment. In the poorer districts of the city of London,

Dr. Letheby found that the amount used was 5 gallons per individual daily, and in model lodging-houses, according to Mr. Muir, 7 gallons. In the cottages of the poor in country districts where water is scarce, the amount in many instances does not exceed 3 gallons, but then the inhabitants are not cleanly. A sponge-bath daily will require 3 to 4 gallons, while a plunge-bath will take from 40 to 60 gallons. Where water-closets are used, an additional allowance of from 4 to 6 gallons must be provided. Latrines require a less amount. The amount required by cattle and horses is 6 gallons and 8 gallons per animal respectively.

The late Professor Rankine's estimate was 10 gallons daily per individual for domestic purposes, 10 for municipal purposes, and 10 more for trade purposes in manufacturing towns, and this amount, large though it seems, is actually supplied to many towns at the present day, and sometimes largely exceeded. Glasgow, for example, receives 52 gallons daily per head of population; Edinburgh and Southampton 35; Paris 31; and Liverpool 27. The different London water companies supply from 26 to 47 gallons—the mean average being 31·1. Sir Robert Rawlinson's minimum estimate for manufacturing towns is 20 gallons per head daily, and if care be taken to prevent needless waste this will be sufficient.

As regards the relative amounts used in towns for domestic, municipal, and trade purposes, the following table from a paper read by Mr. T. Duncanson, A.M.I.C.E. before the Liverpool Engineering Society in April 1894 is of interest:—

Name of Company or Town.	Year.	Domestic Supply in Gallons per Head.	Trade and Public Supplies. Gallons per Head.	Total Gallons per Head.	Percentage of Supply. Given Constant.
Liverpool . .	1893	17·10	9·8	26·9	100
Bradford . .	1891	18 to 20	20·0	38 to 40	100
Manchester . .	1893	15·0	9·0	24·0	100
Birmingham . .	1893	17·0	8·75	25·75	100
Glasgow . . .	1893	36·0	16·0	52·0	100
St. Helens . .	1893	18 to 21	18 to 20	36 to 41	100
Swansea . . .	1893	23·4	4·2	27·6	32

Taking Birmingham and Manchester as types of different manufacturing towns, it would appear from the above that an estimate of 15 gallons for domestic supply, and 5 gallons respectively for municipal and trade purposes, or a total of 25 gallons per head daily, would be ample. It should also be noted that in the above table, the amount of waste is included in the quantities given for domestic supply. There can be no question, however, that the amount of water habitually wasted in many towns is enormous, reaching in all probability to at least one-third of the supply, and this, when the water has to be pumped into the town, or when the town sewage has to be pumped or chemically treated in any way at the outfall, increases the rates to a very considerable extent. While part of this waste is due to underground leakage from pipes and mains, by far the larger portion of it is due to imperfect household fittings, and to carelessness in leaving taps running.

For hospitals the daily amount per patient may be estimated at about 60 to 70 gallons. The amounts per head daily used in different hospitals are as follows:—London Hospital, 102 gallons; St. Thomas's Hospital, 99; Netley Hospital, 70 gallons. In prisons and workhouses the quantity will vary according to the bathing arrangements, and whether water-closets are used. In the Old Convict Prison, Portsmouth, where water-closets and water-latrines were both used, and where each prisoner was allowed a general bath once a week, I found that the amount averaged about 11 gallons per convict daily.

Section III.—Modes of Supply

This part of the subject has reference to springs, wells, borings, the collection and storage of water, and to water-works generally.

1. *Springs.*—Springs are natural outlets of underground water, and are usually divided into land and main springs. Land springs are the outlets of limited collections of underground water formed in beds of gravel or land overlying a

stratum of clay. They are often intermittent, and may become dry during the summer months. Main springs, on the other hand, flow from a geological formation overlying an impermeable stratum which crops out on the surface at a lower level than the line of infiltration. Although the flow of main springs is perennial, it is generally subject to seasonal fluctuations, being greatest in February and March, when the level of the underground water stands highest, and least in September or October, when the level of the underground water is lowest. Springs afford good sources of supply for villages or small communities, but when the yield is intermittent or fluctuates, considerable storage is rendered necessary.

2. *Wells and Borings.*—In villages and rural districts surface wells, whether as ordinary pump wells, draw wells, or shallow dip wells, constitute the usual source of supply, and though they may naturally yield a wholesome water, the surrounding soil often becomes so saturated with impurities that it is next to impossible to prevent their pollution. In crowded localities, therefore, they should always be regarded with suspicion, and, as far as possible, their use should be discontinued. Deep wells, on the other hand, are not open to this objection, because they are generally sunk through an impervious stratum, which prevents the infiltration of any surface impurities, and at the same time serves to keep down the water in the porous strata beneath. The quality of the water from these wells, as has already been shown, will depend on the nature of the geological formation of the district. It is also apparent that, in accordance with a well-known physical law, it is only necessary to bore through the impervious stratum, and reach the water-bearing bed, for the water to rise to the surface, or to within a short distance of it, so as to be collected in a well of ordinary dimensions. Indeed, in certain low-lying districts, where a boring is made at a point considerably below the level of the line of infiltration into the water-bearing stratum, the water rises above the surface and overflows. Deep wells, supplemented by

borings and adits, are very common in the chalk and new red sandstone districts, and are made to increase the yield of the wells. Practically, it is found that one boring adds to the supply of a well nearly as much as several. Thus in the old Bootle well at Liverpool, with 16 bore-holes, some of which were 600 feet deep, Stephenson found that when all were plugged up but one, the yield was 921,192 gallons per day, and when all were open, it was only increased by 112,792 gallons.

Deep wells are now being abandoned for the supply of large towns, because they are found to be insufficient for the wants of a rapidly-increasing population, and obviously cannot be multiplied within a given district beyond certain limits, because every single well drains a surrounding area of some considerable extent. For large isolated buildings, however, such as lunatic asylums, workhouses, and prisons, they usually supply the whole of the water required; and in selecting a site in the country for any such building, the possibility of obtaining the requisite water-supply, and the cost at which it can be procured, are points of the first importance.

Generally speaking, the chance of obtaining a good supply will depend upon the nature of the underlying strata, and upon the level of the proposed site. Wells sunk in superficial sand or gravel beds, though yielding a good supply at ordinary times, are very liable to have their yield very much lessened in seasons of drought, unless they are situated at points considerably below the level of the surrounding country, and the same remark applies to surface wells in the chalk districts. On the other hand, deep wells or borings in the new red sandstone, and oolite or chalk formations, usually yield a large and constant supply, because these permeable rocks are so saturated with water that they may be regarded as vast subterranean reservoirs. Artesian wells, so-called from Artois in France, where the famous Well of Grenelle was sunk in 1835, are bored through impervious, into pervious and water-bearing, strata, and the water may rise to a considerable height if the water-bearing strata upheave on

either side much above the level of the mouth of the well. The water in the well at Grenelle rose to a height of 60 feet above the surface of the ground, when the boring was carried to a depth of about 1800 feet. The artesian well at St. Louis, U.S.A., is 3843 feet deep, and those in Dakota, U.S.A., which are remarkable both for the volume and pressure of water, vary from 500 to 1600 feet deep. In upland farms in Australia, these artesian wells have been attended with a considerable amount of success, while in South Africa and America, large tracts of land are being irrigated by the water supplied from deep borings.

The relation of springs, shallow wells, and deep or artesian wells, to pervious and impervious strata stretching across a valley line is illustrated in the following diagram :—

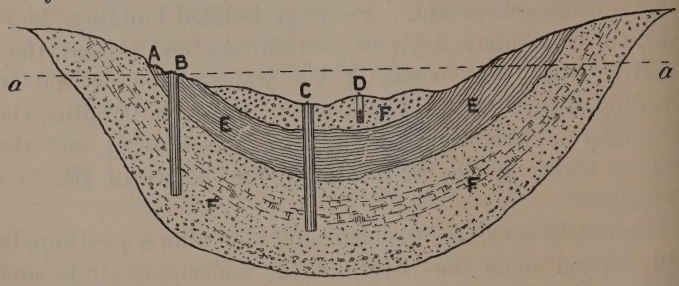


FIG. 8.—*a a*, LINE OF SATURATION OR LEVEL OF UNDERGROUND WATER IN DEEPER PERVIOUS STRATA, F F.

A, spring cropping out above impervious strata, E E.—B, deep well, and C, over-flowing artesian well, bored through impervious, into pervious, strata, F, F.—D, shallow or surface well sunk into overlying pervious strata, F.

The following are some of the towns which are supplied by deep wells :—Canterbury, Cambridge, Bury St. Edmunds, and Deal, from the chalk formation ; Birkenhead, Coventry, Leamington, and Southport, from the new red sandstone ; and Bedford and Scarborough from the oolite.

For a small or temporary supply, the Abyssinian or tube well has been found to be very useful. It consists of a narrow iron tube driven into the ground in lengths, the lower part being pointed and perforated at its end, and is fitted with a single or double action pump according to the depth. The water enters the tube through the perforations,

and, if the bed is sandy, has to be filtered for some time, until, by gradual removal of the sand, a well is formed around the lower end, and the water is obtained without sediment. This pump is especially adapted for country districts, and it possesses the further advantage of helping to keep out surface impurities.

In order to ascertain the yield of surface wells, the transverse area of the well, and the height at which the water stands, must first be ascertained, after which the water is pumped out, and the time noted which is required for refilling. The yield of small springs can be readily measured by receiving the water into a vessel of known dimensions, such as a cask, and also noting the time which it takes to fill. (See Appendix.)

3. *Waterworks.*—In addition to deep wells, waterworks on an extensive scale obtain their supply from lakes, streams, rivers, or gathering-grounds. When lakes are used as reservoirs, they are generally of sufficient elevation above the level of the town to be supplied to permit of the water being freely distributed to the highest points by gravitation; but in order to secure ample storage or prevent undue interference with various vested rights, it is usually found necessary to raise the level of the lake by constructing a barrier at the outlet varying in height according to the area of the lake and the quantity of water required. Thus, in the case of Loch Katrine, which supplies the city of Glasgow, and covers an area of 3000 acres, it was found necessary to construct a barrier 4 feet in height, in order that with a maximum lowering of 7 feet it might provide a storage of 5687 million gallons for a supply of 50 millions per day; while Thirlmere, with an area of 350 acres, requires a barrier 50 feet in height to provide a storage of 8100 million gallons for a similar daily supply for Manchester.

If the source of supply is a stream or small river, storage works are necessary; but when the river is large, a constant supply can be obtained at all times, independently of storage. In this case the works required usually comprise—a weir

or dam for maintaining part of the river at a nearly constant level; two or more settling reservoirs, into which the water is conducted; filtering beds, and pumping engines.

When it is required to ascertain the yield of any small stream, it is usual to employ a weir gauge to dam up the water into a pond behind, and allow it to flow through a sluice, or over a sill of known dimensions. In the case of an average-sized stream, a rough approximation of the yield may be obtained by taking the breadth and depth at several distances in a short section of the channel which is tolerably uniform, and thus ascertaining the average sectional area. The surface velocity may then be taken by noting the time occupied in floating a light object over the selected distance, and as four-fifths of the surface velocity are about equal to the actual velocity, the yield in cubic feet or gallons per second can be easily calculated (see Appendix).

When the water-supply of a town is collected from small streams or gathering grounds, the rainfall of the catchment basin and its available amount are items which ought to be carefully inquired into.

The average annual rainfall in different parts of this country varies from 22 to 140 inches, the least recorded depth being 15 inches. It is greater in mountainous, than in flat, districts, and on the leeward side of a mountain ridge than it is on the side facing the prevailing winds. As regards water-supply, the most important data are the least annual rainfall and the longest period of drought.

In selecting drainage areas, it must be borne in mind that the nearer to the surface the actual rainfall water is collected the freer it will be from impurities, and that purity of water and fertility of soil are not to be expected together. Water collected from a peaty soil will contain large quantities of vegetable matter, while that from a soil well cultivated will be tainted with animal impurities. The purest water, therefore, which can be collected from drainage areas is found in the barren moorland districts of the primary geological formations, or of the sandstone rocks.

The channels of the gathering ground may either be the

natural watercourses of the district, or these may be supplemented by adits, closed drains, or open ditches. The latter, however, are objectionable because they form receptacles for vegetable matter, and as the current in them must be necessarily slow, there is considerable loss by evaporation. The position, extent, and dimensions of the adits leading to the reservoir will depend upon the configuration of the district. The reservoir itself is generally a natural hollow, situated in the valley-line of the catchment basin, and of sufficient elevation to procure a fall, so that the water can be distributed without mechanical means being required to raise it. In this country the storage room should be large enough to contain a four or six months' supply and sufficiently capacious to meet the requirements of an increasing population for thirty or fifty years to come. The site, which can supply the requisite storage room with the least embankment, the least amount of puddle, and the least area laid under water, is to be preferred.

Upon the strength and stability of the embankment everything depends. It is made water-tight by a core of clay puddle, the inner slope being protected from the action of the water by a pitching of dressed stones, and the outer, from the effects of the weather, by a covering of grass sods. The puddle core generally amounts to a tenth of the whole embankment. The height of the embankment varies from 3 to 10 feet above the highest water level, the top being covered with broken stones. No trees or shrubs are allowed to grow upon it, and the greatest care is taken in its construction to prevent animals, such as water-rats, burrowing into it.

Every impounding reservoir, as it is called, is provided with an overflow weir to permit the discharge of the flood supply from the drainage area, and this is often supplemented by a channel termed the *by-wash*, which is used to divert the streams supplying the reservoir, so as to prevent fouling of the store-water. The flood-water carried off in this way flows into the natural watercourse.

In order to remove the sediment which collects in the bottom of the reservoir, there is always a cleansing-pipe as well as a discharge-pipe, the former being on a level with the lowest point in the reservoir, and discharging into the natural watercourse below the embankment. Both are carried through a culvert in the embankment, which is built of stone or brick, and founded on the solid rock. The aqueduct or discharge-pipe bends upwards in the reservoir, and has a series of inlets, the lowest at the lowest working level, and the whole of them guarded against the entrance of small stones, pieces of wood, or other bodies, which would interfere with the action of the valves. The sluices which are required for both pipes are situated in the reservoir, and are worked from the sluice-tower.

The aqueduct is that portion of the conduit leading from the reservoir to the distributing mains. It may be open or close throughout, or partly close and partly open. Where close, it consists of a train of cast-iron pipes securely jointed, bedded on a firm foundation, and covered to a depth of at least 2 or 3 feet to preserve them from frost. Sluice stop-cocks are provided in the valleys, for the purpose of scouring out any stones or sediment, and, at intervals not exceeding half a mile, to permit of repairs. Valve-cocks are supplied at all the principal summits to allow the escape of air. When the aqueduct is partly close and partly open, or if, when close, it cannot withstand the whole pressure when the demand ceases, either a system of weirs is required to discharge the surplus water, or one or more store-reservoirs are provided, resembling in general plan and construction the impounding reservoir.

4. *Distribution.*—The distributing mains also consist of cast-iron pipes, and are coated, like the aqueduct pipes, with pitch, or Dr. Angus Smith's varnish, to preserve them from corrosion. The magnetic oxide of iron produced on the surface of the metal by Barff's process answers the same purpose and is coming into use. Pipes should have turned and bored joints, or the joints should be run with lead and not be caulked with tow or gaskin next the interior of the

pipes. The same details with regard to sluice-cocks and stop-cocks are observed in the different bends of the tracks, with this addition, that the dead ends or terminations of the branch and main conduits are supplied with scouring-valves, through which stones and sediment can be washed. Dead ends, however, should as far as possible be dispensed with, and the mains be connected by an interlacing system so as to ensure the greatest obtainable circulation.

As the greatest hourly demand for water is about double the average hourly demand, the main conduits supplying a town must have double the discharging capacity which would be required if the hourly demand were uniform. The additional expense in piping which would be thus entailed is sometimes so great that distributing basins or town-reservoirs are constructed to supply certain districts. To meet all emergencies, they are made large enough to contain at least a day's supply, and they must also have a site of sufficient elevation to ensure distribution by hydrostatic pressure. Every such reservoir should be roofed in and ventilated, to protect the water from frost and heat, and from becoming tainted with aerial impurities.

In wide streets, or in streets with much traffic, there is generally a service-main for each side, in order that the house-pipes may be as short as possible, and may be accessible without disturbing the traffic. The house service-pipes are usually made of lead, and though they are liable to be acted upon by some waters, the readiness with which they can be adapted to all the bends and curves rendered necessary in carrying the piping to different floors of houses, gives them a preference to all other kinds of metal pipes. The waters which act most on lead are the most highly oxygenated, and those which contain organic matter, nitrites, nitrates, and chlorides; those which act least on it contain salts of lime and magnesia, as they coat the metal with sulphate, or basic carbonate, of lead. When silica is present, even in minute traces, the action on lead is very slight. Moorland or peaty waters, on account of their softness and because they contain vegetable acids, act upon lead very

freely, and several outbreaks of lead-poisoning due to this cause have been recorded, notably at Huddersfield and Sheffield, and at Pudsey in Yorkshire in 1892. At Pudsey the plumbo-solvent action of the water was remedied by adding chalk in the proportion of three grains to one gallon of water, and at other localities filters of gravel, broken flints, and lime, have been adopted with good results. Various means have been proposed to protect the lead from corrosion, such as coating with bituminous pitch or with coal-tar; but when the quality of the water renders lead pipes objectionable, properly protected, or tin-lined, iron pipes make the best substitutes. All the leaden service-pipes of a house should be strong (12 lbs. per lineal yard for one-inch pipes, and 6 lbs. per yard for half-inch pipes), to withstand pressure. Distributing mains and house-service pipes should be laid at a depth of 3 feet to protect from frost.

5. *Constant and Intermittent Systems of Water-Supply.*—The water thus distributed to the various houses in a district is supplied either on the intermittent or the constant system. The intermittent system necessitates storage in house-cisterns, and is attended by so many disadvantages that the constant system should always be adopted wherever it can be carried out. The use of cisterns, except on a small scale for water-closets and boilers, is open to the great objection of the risk of contamination of the water, for not only are the cisterns liable to become fouled if not sufficiently protected against the entrance of aerial and other impurities, but the water always becomes flat and insipid. Moreover, in poorer districts, the cisterns are often of a very inferior description, are badly situated, and are seldom inspected or cleaned out. It is further urged against the intermittent system that the distribution pipes, being alternately wet and dry, are liable to collect dust and the effluvia from sewers or drains, or neighbouring gas mains. The objections to the constant system, on the other hand, are the great waste when the fittings are imperfect, and an insufficient delivery in parts when the water-supply is not abundant. The diameters of the pipes for constant service should therefore be carefully adapted to

their discharges and to the head of pressure, so that an extra flow of water in one district would not interfere with the requisite supply of other parts. In large towns, where some parts are much lower than others, care has to be taken that the mains and branches in the lower parts are not exposed to excessive pressure, and this is obviated by causing "loss of head" either by passing the water through small inlets or by the use of loaded valves. With proper fittings, strict regulations, and efficient supervision, it is now clearly established that a constant supply requires a less amount of water than an uncontrolled intermittent supply, so that even on the score of economy the constant system is to be preferred.

In order to prevent undue waste, water-meters are sometimes applied to the service-pipe supplying a group of houses, and the landlord charged for the amount used; but as this plan induces the landlord to enforce a too rigid economy, it is not to be commended. The best water-meters are capable of registering exactly all amounts exceeding a flow of one gallon per hour; but when the water contains a considerable amount of undissolved impurities, and is badly filtered, they very soon become clogged up, and fail to register anything like the quantity of water which may pass through them.

In order to detect waste, meters, such as Deacon's, Tyler's, Kennedy's, and others, are of great service. When these meters are placed on district mains they register the flow of water by day and night, and the amount found flowing through any particular main during the night, when there is no consumption, indicates the amount of waste. After localising the waste, the particular spots where the leakage occurs can be detected by auscultating the nearest house-pipes. It is obvious, however, that such waste-preventing meters cannot be used on any portion of an interlacing system, unless they are attached to near the ends of the distributing mains, and each controlled by a valve to isolate a particular area.

In addition to the arrangements for domestic supply,

outlets or hydrants with valve-cocks are provided on the service pipes of all large towns, at regular intervals, in case of fire, and for supplying water to flush the gutters and water the streets. It is also of great importance that the separation between water mains and sewers, drains, or gas-pipes should be as wide as possible. Whether the water-supply be on the constant or intermittent system, the risk of suction of gases or fluids into leaky mains is imminent, though of course much less when the supply is constant. Unfortunately, however, this danger of contaminating public water-supplies has hitherto not been appreciated, and indeed in many towns it has been enhanced by arrangements for flushing sewers directly from the mains.—(See Simon's *Reports,* New Series, No. VII.)

Section IV.—Rural Water Supplies

It is estimated that about one-third of the population of Great Britain obtain their water-supply from shallow wells, the majority of which, owing to situation and faulty construction, are more or less polluted or liable to pollution, and that vast numbers have still to depend on pools, ponds, intermittent land springs, or rain-water storage. For convenience sake almost all wells are sunk close to the premises, but where the level of the ground water is within easy reach, say 25 feet deep or less, there is no reason why a well should not be sunk at a safe distance from all sources of pollution, such as drains and the like, and yet have the pump fixed in the kitchen. This can often be effected by what is called a "side-draught," that is by laying a pipe reaching to the bottom of the well at a minimum depth of three feet to protect from frost and connecting it with the pump. Before sinking a well the position should be carefully selected, and especially in relation to the flow of the subsoil water. If sunk through a porous subsoil the brick work, instead of being loosely laid, as is the usual practice, should consist of blue brick laid in cement down to a depth of 10 or 12 feet, and this again should be surrounded with

clay puddle. Or instead of a brick and cement lining, earthenware tubes of 2 ft. 6 in. or 3 ft. inside diameter may be used. Dry-steined wells at present in existence could readily be protected in either of these ways, and further protection ensured by projecting the dome or top of the well 6 or 12 inches above the surface, and securely covering it by a properly fitting iron cover, or a stone slab carefully adjusted and sealed with cement. This manhole is necessary for inspection and cleansing, and around it, for a distance sufficient to cover the area of the well and the clay puddle surrounding it, there should be a paving of blue brick laid in cement and sloped to a gully leading to a drain, if the pump is fixed directly in or over the well. It is preferable, however, either to fix the pump in the house as already pointed out, or at some little distance from the well, and a curved or hooded pipe should be provided for ventilation.

In order to prevent surface pollution, Koch in his work on *Water Filtration and Cholera*, has recommended that existing wells should be cleaned out and filled up to the highest water level with gravel, and over the gravel, with sand, up to the surface. An iron pipe with perforated end should traverse the sand and gravel, and be properly connected with the pump. This suggestion, if carried out, would afford the same protection against the entrance of surface impurities as that secured by the Abyssinian tube well already described.

All dip or draw wells should, whenever possible, be converted into pump or tube wells, because they are especially liable to pollution. If the depth of a well does not exceed 25 or 30 feet, the ordinary suction pump is sufficient, but for greater depths a forcing pump is necessary, and hence it is that, to save expense, open wells provided with bucket and windlass are still so frequently met with. Wooden pumps, though affording protection against frost, are open to the objection of yielding an unpleasant taste to the water for some time after they are fixed, and subsequently becoming liable to decay.

Where the underground water is not within easy reach, or in crowded villages, where the subsoil has become dangerously polluted, public supplies becomes necessary; and even in thinly-populated areas, the difficulties to be faced in carrying out adequate schemes have been greatly exaggerated. Simple and inexpensive supplies can often be obtained from a spring of such an elevation as to give sufficient head for conveying the water from the storage tank to hydrants or stand-pipes along the route. If pumping is required, the motive power may sometimes be provided by means of a ram, turbine or water-wheel, or windmill, though this last necessitates an extra amount of storage; or a gas or oil engine, either of which will require but little attention, so that the labour bill will be comparatively trifling.

Dr. Thresh, in his work on *Water Supplies*, gives instances in which some of these various schemes have been very successfully carried out, and at a comparatively small outlay. For example, at Danbury in Essex, the public supply is obtained from a spring a mile distant and 180 feet below the highest point to be supplied. The water is forced by a ram to a tower tank of 4000 gallons capacity, and flows through three miles of mains. About 60 houses out of a total of 195 have the water laid on, and stand-pipes supply the remainder. Only those houses are rated which are actually supplied, or are within 200 feet of a stand-pipe. The total cost was £807. The rate is 1s. in the pound, and produces within £2 the whole of the annual sum required to pay off the principal and interest in thirty years, the balance being paid out of the parish rate. Another village in Dr. Thresh's district, with a population of about 1000, is supplied by subsoil gravitation works. The water rate in this instance is 9d. in the pound, and the water is laid on to all the houses.

For the hamlet of Cessbrook, near Buxton, the water is raised from a spring by a breast water-wheel. The quantity guaranteed to be delivered into the reservoir, which has a capacity of 35,000 gallons, is 4000 gallons per day, though this amount can be trebled without running the

wheel and pumps at excessive speed. The water-wheel works a three-cylinder pump fixed in a cistern of 120 gallons capacity, into which the spring water is conveyed by a 3-in. pipe. The total cost, which was borne by the owner of the estate, was a little under £1000. The water is laid on to fifteen stand-pipes, and the charge for each cottage is $1\frac{1}{2}$d. per week.

At Lechdale, in Gloucestershire, a windmill made by the Ontaria Company is used for pumping the water from a well into a tower tank built over the well, and of 60,000 gallons capacity. The well is a tubular well of 4-in. bore, and is driven to a depth of 24 ft. through a stratum of clay into the water-bearing bed of gravel beneath. The tower is 10 ft. high, in which the pumps are placed, and on the top of this is the windmill, which has an automatic action, shutting off when the tank is full, and collapsing when the wind pressure is too high. The supply has never failed during the four years the work has been in existence, the storage having proved ample to tide over periods of calm. The number of inhabitants supplied is about 1000, out of a total parish population of 1250. The water is supplied to stand-pipes; but any house can have the water laid on at a rate of 10s. yearly. The total cost of the works was £1800, which was borrowed by the Sanitary Authority to be repaid in thirty years, and to meet this a water-rate of 3d. in the pound is sufficient.

Another village supply, instanced by Dr. Thresh, and minutely described by Dr. Ashby of Reading, is that of the village of Sonning in Berkshire, with a population of 515. The water is obtained from a boring 75 feet deep in the upper chalk, and is pumped by an oil engine of two brake horse-power, into a reservoir of 35,000 gallons capacity. The total cost of the works was £1840, and to repay the annual instalments of principal and interest as well as cover the cost of pumping, a rate of 1s. on houses and 3d. on land is required. The additional charges are 7s. a year on houses under £14 rateable value, and $2\frac{1}{2}$ per cent on the rateable value of all other houses into which the water is

laid on. There are also some extra charges for farmyards, cow-keeping, and livery stables. The rateable value of the parish is only £4398, but the supply and works are sufficient to supply a considerably larger community.

There is no doubt that the somewhat unfair incidence of rating is the great stumbling-block in the way of the much-needed provisions of water-supplies for villages and scattered rural populations, but the above examples show that even the question of rating and of imposing charges is by no means so serious as is generally assumed, while the engineering difficulties can nowhere be regarded as insurmountable.

Section V.—House Service Pipes and Water Fittings

In many parts of towns and villages provided with public water-supplies, stand-pipes are used for the supply of groups of houses. All these should be protected against frost in winter, and to prevent waste as far as possible, the tap should be of the "screw-down" or "waste preventer" kind. Except under special circumstances, no house supplied directly from the mains should have more than one service or "communication" pipe, which should be laid at a depth of at least 2 ft. 6 in. (preferably 3 ft.), or otherwise protected against frost, and properly safeguarded against insuction of ground air or other impurities. Every such communication pipe should be provided with a stop-valve of the screw-down kind to permit of the water being turned off for repairs or leakage, and if the valve is placed in the ground, it must be protected by a proper cover and "guard-box." No pipes should be taken up outside walls, and wherever they are so exposed as to be liable to be affected by frost, they should be encased with felt or boxed in with sawdust. When they run horizontally, care must be taken that they are laid on continuous supports and on a slope sufficient to permit of the contained water being run off when necessary.

As already pointed out, lead-piping is generally used, but when the water-supply possesses plumbo-solvent properties, the pipes should be of tin-lined iron, galvanised wrought iron, or "steam piping." If the pipes are of lead, the joints should be properly "wiped" joints, but if of iron, short lengths should be freely used, and all the junctions screw-jointed. The diameter of the communication pipes should vary from $\frac{1}{2}$ in. to $1\frac{1}{4}$ in. according to requirements, though in some towns the minimum diameter is only $\frac{3}{8}$ of an inch. All draw-off taps should be of the screw-down kind, and no pipe should communicate directly with any closet, urinal, or boiler.

When the water-supply is constant, no cisternage is required except for closets, urinals, housemaid sinks, or boilers, but where the supply is intermittent, or in respect to country houses supplied by well and force-pump, storage cisterns become necessary. Indeed, in London and other large towns, these cisterns are still common, even with a constant supply, but in all such cases the water for domestic use should always be derived directly from the mains, not only in the kitchen and scullery, but also on the upper floors, when required for filling bedroom bottles. In most of the best houses, which are still provided with storage cisterns, the taps which deliver water from the mains are marked "main," and those which deliver water from the cistern are marked "cistern." But whenever possible, the use of storage cisterns should be avoided.

When cisterns are required, they are usually made of slate, galvanised iron, glazed earthenware, or lead, but lead should never be used for storage of drinking-water. Slate set in good cement is an excellent material, and so is glazed or enamelled earthenware, though its weight is a disadvantage. Iron cisterns, if not protected by a lining of cement (Crease's patent), very soon rust and discolour the water. On the whole, galvanised iron cisterns are the most suitable, and though a little zinc may sometimes be given up to the water, it is so infinitesimal as to be inappreciable. To permit of periodical cleansing it is pre-

ferable to have two small cisterns instead of one large one, and to protect from dust, soot, and the entrance of animals such as mice, rats, etc., all cisterns should be properly covered. If exposed to risks of frost, the sides should be made to slope upwards and outwards to prevent fracture by the expansion of the freezing water. No cistern which supplies water for domestic use should directly supply a water closet, housemaid's sink, or urinal,—a waste-preventing, or separate small, cistern should always intervene. The inlet pipe to every cistern should be provided with a "ball-tap" or valve-cock controlled by a float to rise and stop the supply when the cistern is full, and the overflow or "warning" pipe should be made to discharge into the open, and in such a position as to be readily detected, or it may be made to discharge on to the kitchen or scullery sink.

In good class houses, hot-water supplies are generally provided for baths and lavatories, and sometimes also for warming and ventilating purposes. The common forms of boiler are adapted for use with kitchen ranges, and are placed at the back of the fire and shaped so as to obtain the greatest possible heating surface. In the earliest kind of apparatus, known as the worm-boiler system, the feed-pipe leading from a cistern under the roof formed a coil inside the boiler, and was continued up through the house as a hot-supply pipe ending in an open escape over the cistern, while the boiler itself was fed by a small cistern adjoining the range, and was provided with a draw-tap for the supply of hot water in the kitchen, and a boiler escape rising above the level of the small feed-cistern. While this system is free from risks of explosion, it possesses the disadvantage of allowing the hot supply to cool down if much hot water is drawn off from the kitchen boiler.

The best system, and the one now generally adopted, is known as the "reservoir" hot-water service. Its main feature is the interposition of a cylinder, either of galvanised iron or copper, between the cold and hot supply, so that the contained water is heated by circulation from the boiler. Although the feed-pipe in this system is liable to become

frozen in very severe weather, close to the cistern, the danger of explosion is practically obviated, and timely warning would be given by the noise of vigorous boiling in the reservoir or cylinder (see Fig. 8A).

It is preferable to fix the cylinder in the bath-room or a drying-closet, because when fixed in the kitchen, the temperature of the air is often higher than is comfortable.

An inferior, though still very common form of apparatus, dispenses with the cylinder or reservoir, so that the feed-pipe from the cistern under the roof enters the bottom of the boiler, while the hot-supply pipe ascends from the top of the boiler, and after supplying various parts of the house, ends in an escape-pipe over the top of the cistern. In this system, the danger of explosion is greatly increased because both pipes are liable to become blocked during frost on account of their exposed position under the roof. Hence if the fire is lit, and the water begins to boil, no steam can escape by either pipe, or if the feed-pipe only is frozen, the water in the boiler after a time evaporates, the boiler becomes red-hot, and if the cold supply is suddenly renewed, the

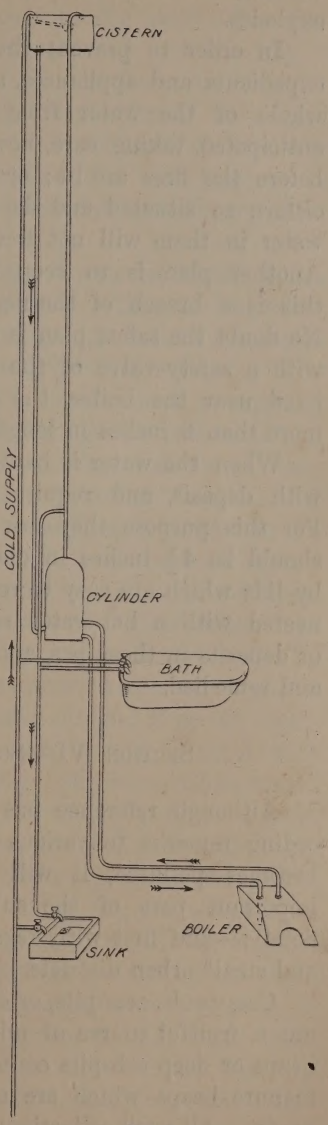


FIG. 8A.

inrush of water is converted into steam and the boiler explodes.

In order to prevent these accidents, there are several expedients and appliances, as for example, to draw off the whole of the water from the cistern when a frost is anticipated, taking care, however, that it is turned on again before the fires are lit; or better still, to have the supply-cistern so situated and the pipes so well protected that the water in them will not freeze during the severest weather. Another plan is to keep taps running during frost, but this is a breach of the regulations of all water companies. No doubt the safest plan is to furnish the boiler or cylinder with a safety-valve of the dead-weight description, and if fixed near the boiler, the connecting-pipe should not be more than 6 inches in length.

When the water is hard, boilers speedily become furred with deposit, and require to be cleaned out periodically. For this purpose they are provided with manholes, which should be $4\frac{1}{2}$ inches in diameter, and kept securely closed by lids which are easy to remove and repack. Noises connected with a hot-water service are generally due to air or deposits in the pipes, and should at once be investigated and remedied.

Section VI—Sources of Pollution

Although reference has already been made in the preceding remarks to various ways in which drinking-water becomes polluted, it will be expedient to consider this important part of the subject somewhat more fully in detail;—and first with regard to the water-supply of rural and small urban districts.

Cess-pools, cess-pits, or drains, in close proximity to wells, are a fruitful source of mischief; and so also are midden-heaps or deep ash-pits connected with privies, and the huge manure-heaps which are allowed to accumulate in farm-yards. All such collections of liquid or solid filth should be regarded as dangerous nuisances, and should either be done

away with altogether, or such adequate precautions taken as will obviate the risk of soakage into the well. The substitution of a dry system of conservancy and the use of pails or boxes for the cess-pool, common privy, and cess-pit, together with better scavenging, would lessen to a very large extent the dangers of well-pollution in country districts; but in crowded localities the soil becomes so saturated with filth of all kinds that surface wells are never safe.

With regard to public supplies, it may be stated generally, that water may become polluted either at its source, in the course of distribution, or through defects connected with its storage. Any supply which is taken from a river polluted by the sewage of towns up-stream must be carefully filtered, and even then it can only be regarded as a suspicious water. Deep wells or springs, on the other hand, may become polluted by the entrance of surface impurities, or by the access of polluted water through open fissures in the rock. But perhaps the most frequent and insidious sources of pollution to which public supplies are exposed are those dependent upon the arrangements for distribution and storage. It has already been pointed out that, with an intermittent supply, the mains must necessarily become full of air when the water is turned off, and if at all leaky, as they very often are, they may become charged with liquid as well as aerial impurities. Moreover, when water-closets are served direct from the mains by mere taps or stop-cocks, there is always the danger of liquid filth being sucked into them whenever a closet-pipe becomes choked up, and the pan becomes full. Then, too, connected with this system of intermittent supply, there are all the risks of contamination attaching to cisternage, or storage in pails, butts, or other receptacles. If the same cistern is used to supply the house and the water-closet as well, sewer gases from the closet have access to the surface of the water in the cistern; or should the overflow pipe from the house cistern discharge direct into a sewer or drain, there is of course the same danger. Apart also from the risk of lead-

pollution from leaden cisterns, the water stored in a cistern may eventually become unfit for use, because the cistern is seldom or never cleaned out.

It has further to be observed that water mains, if not sufficiently protected against corrosion, may render the water turbid, owing to rusting of the iron; that the tow or gaskin employed to caulk joints may taint the water for a long period if the main is several miles in length; and that leaden pipes, especially when first laid down, may become a source of danger if the water is soft, or contain vegetable acids.

Section VII.—Water Purification

Water derived from deep wells, springs, or adits rarely requires purification, and even surface water, if collected in large lakes, as the Liverpool supply from Lake Vyrnwy, or the Glasgow supply from Loch Katrine, becomes so clarified and freed from impurities that no further treatment is necessary. Most waters, however, and especially river water, must be submitted to a process of purification before distribution, and on a large scale this generally consists in passing the water into settling tanks or reservoirs where the heavier suspended matters subside, and from them on to filter-beds.

A filter-bed may be described as a tank or reservoir several feet in depth, with paved bottom, on which are laid a series of open-jointed or perforated tubular drains leading into a central culvert which discharges the filtered water into a storage reservoir. The drains are covered with a layer of gravel of varying thickness over which is placed a layer of clean sharp sand about 2 feet deep. The water is delivered on to the filtering-bed uniformly and slowly, and in order that the filtering process may not be carried on too hurriedly, the pressure is always kept low, the depth of water being seldom above 2 feet, and at some works only 1 foot. Deep filter-beds, however, are always preferable to shallow ones, because the filter is not so liable to be affected

by frost in winter, and the water is kept cooler during the summer months.

The action of a filter so constructed is partly mechanical and partly vital or biological. The mechanical action consists in the retention of the suspended impurities, while the vital action is carried on in the layer of deposit thus formed which is found to teem with micro-organisms, and it is by these organisms, which subsequently penetrate some distance into the sand, that the process of nitrification is effected. Formerly it was believed that in sand-filtration the oxidation of the organic matter was due to the oxygen held in the pores of the sand, but it has recently been clearly established that it is entirely attributable to these nitrifying organisms. A new filter, therefore, fails to accomplish bacteriological purification until this layer of sedimentary gelatinous matter is formed on the surface, and so long as it does not seriously impede filtration it should not be disturbed. When the filter becomes clogged, so to speak, this layer requires to be scraped off, and at each such cleansing operation about a quarter to half an inch of sand is also removed. A fresh supply of sand is added when the depth of the layer is reduced to an extent which threatens to impair the efficiency of the filter, but when possible it is also advisable to reject all water which passes through the filter until sufficient time has been given for the formation of a fresh layer of microbial and sedimentary deposit.

According to a series of experiments which were carried out by the State Board of Health of Massachusetts (see Annual Reports 1891-93), filters required three days' use after scraping to reach their maximum degree of efficiency, and it was found that by carefully regulating the rate of filtration through a properly constructed sand filter about 99·9 per cent of known numbers of the *bacillus prodigiosus*, which had been previously introduced into the water, had been removed. These experiments have been confirmed by Koch, and they go to prove that sand-filtration, when efficiently carried out, is a safeguard against water-borne diseases, though it cannot guarantee absolute protection.

But he lays down two conditions, namely, that the thickness of the layer of sand should never be allowed to get less than 30 c.m. (11·8 inches), and that the rate of filtration should not exceed 100 m.m. (3·94 inches) per hour. According to the Massachusetts experiments, it was proved that water could be filtered at the rate of 2,000,000 gallons per acre daily, with the removal of practically all the disease-producing germs which may be present in the unfiltered water. Koch's test of efficient filtration is that the number of germs capable of development should be less than 100 in 1 c.c. of the filtered water, and that such germs are not pathogenic.

Other filtering media, such as magnetic carbide of iron, and spongy iron have been used for purifying town-supplies, but though they act chemically, as well as mechanically, they cannot be said to sterilise water. Spongy iron, which is produced by roasting hæmatite ore, has been employed on the large scale at Antwerp and other continental towns, and is said to give satisfaction; but it must be kept constantly covered with water, otherwise it dries up and readily cakes. Magnetic carbide of iron, which is prepared by roasting equal parts of hæmatite ore and sawdust in a retort, has been used at Wakefield and other towns. Amongst other media, polarite and carferal have been recommended, but it is now generally admitted that none of these substances possess the advantages of sand and gravel for the filtration of public supplies.

For domestic filters, animal charcoal was formerly the material most generally used, but it is open to the objection of yielding nitrogen and phosphates to the water, which favour the growth of micro-organisms. Indeed, Professor P. Frankland found by experiment that, though for some days animal charcoal removed most of the bacteria, it gradually lost this power, and before the end of a month the filtered water contained many more germs than the unfiltered. There is no doubt that it possesses remarkable decolorising and oxidising properties, but it speedily becomes foul and taints the water, and of all filtering media is,

perhaps, the most unreliable and unsafe. Much preferable filtering media are spongy iron, magnetic carbide, and carferal. Bischoff's spongy iron filter, besides removing organic matter, lessens the hardness, and possesses the further advantage that it does not require aeration, because it should always contain sufficient water to cover the filtering medium, which should be renewed about once a year. In Maignen's "Filtre Rapide," asbestos cloth is used, and a substance called carbo-calcis, but beyond clarifying a water, and oxidising the organic impurities to a certain extent, none of these numerous media can be said to sterilise a water.

The best filters which can be recommended for domestic use are the "Pasteur-Chamberland" filter, and the "Berkefeld" filter. Both of them are high-pressure filters, and can, therefore, be attached to a tap or service-pipe, and regulated so that the pressure does not exceed two atmospheres; but in the absence of pressure from a pipe, the requisite pressure is provided by a simple mechanical contrivance. In houses supplied by a force-pump, sufficient pressure would be obtained by affixing the filter to the tap over the kitchen sink or anywhere on the service-pipe, provided it is placed about 20 feet below the cistern supplying it. Each of these filters is made in the form of a cylinder or "bougie," the former of fine porous porcelain, and the latter of infusorial clay.

The bougie is enclosed in a metal or glass jacket, so that the water is filtered through the sides into the interior of the bougie, which is provided with a tap. The rate of filtration is slow, being about two or three quarts per hour by a Pasteur-Chamberland single-tube filter, and double that quantity by a Berkefeld filter, but the quantity of water filtered can be increased by increasing the number of bougies, and thus forming a cistern-filter. Both of these filters are bacteriological filters, and, though they do not oxidise dissolved organic matter, they effect the removal of all suspended matter and micro-organisms, but in the latter respect the Pasteur-Chamberland has been ascertained by

Dr. Sims Woodhead to be much the superior of the two. Indeed, since its adoption by the French War Department, it is stated that typhoid fever among the troops has been reduced 50 per cent. As the suspended matter and bacteria removed from the water remain on the surface of the bougies or cylinders, they can be easily brushed and washed off, and the cylinders themselves can be re-sterilised by being placed in warm water and boiled for an hour.

Sponges are sometimes recommended for domestic filters, but they soon become foul. Asbestos is a much preferable material, because it can be readily cleaned by burning.

Hard waters may be softened on the large scale by what is known as "Clark's process," by adding one ounce of quicklime per hundred gallons for every degree of temporary hardness. Spring waters in the chalk districts are all more or less "hard," and many of them contain such a large amount of calcic carbonate in solution as to be unfit for washing purposes. Such a water, when it is to be rendered "soft" by Clark's process, is let into a tank or reservoir, where it is mixed with a proper proportion of lime water and allowed to settle, the whole of the calcium being precipitated as calcium carbonate. A perfectly clear and wholesome water is thus obtained, well suited for domestic purposes. What is known as the "Porter-Clark process" is a modification of Clark's process, but instead of waiting for slow subsidence, the precipitated calcium carbonate is removed rapidly by filtration through cloth under pressure. This process of softening is founded on the fact that carbonate of lime, or chalk, is almost insoluble in waters which are free from carbonic acid, though soluble in those containing the acid in solution. When, therefore, a solution of burnt lime is added to such a water in the exact proportion indicated by its hardness, the lime combines with the carbonic acid to form a carbonate which falls down with the original carbonate,—the solvent power of the carbonic acid being withdrawn thus:—

$$CaCO^3 + CO^2 + CaH^2O^2 = 2CaCO^3 + H^2O$$

Water is softened by boiling because the carbonic acid is

driven off, and the calcium carbonate being no longer held in solution, is deposited as chalk.

Alum has often been used in Eastern countries to purify water, by throwing down suspended matters, and it does this all the more effectually if the water contains calcium carbonate. A precipitate of calcium sulphate and aluminum hydrate is formed which, on falling, carries with it the floating particles. Distillation on a large scale has also occasionally to be resorted to, and, if properly carried out, should afford complete protection. Under ordinary circumstances, suspicious waters should always be boiled before being used.

CHAPTER VIII

WATER ANALYSIS

Section I.—Collection of Samples

In collecting water for analytical purposes, and particularly when it is intended to submit samples to a quantitative analysis, the following directions should be observed:—An ordinary glass-stoppered Winchester quart bottle will answer very well for the conveyance of the water. It should be cleaned out with strong sulphuric or muriatic acid, then rinsed with ordinary good water until the rinsings are no longer acid, and finally washed out with some of the water to be examined. The bottle should be filled almost up to the neck, stoppered, and the stopper covered over with a piece of clean calico, wash leather, or gutta-percha tissue, tied, and sealed. No luting should be used except sealing-wax, and even that should be dispensed with if possible.

In collecting pond or lake water the bottle should be plunged into the water as far as possible from the bank, with the mouth well under the surface, so as to avoid the scum, care being taken, at the same time, that the mud at the bottom is not disturbed. If the sample is taken from a town supply, it should be drawn from taps directly from the mains, and these should be allowed to run some time before collecting, unless it is desired to ascertain the maximum impurity. With regard to river water, it is recommended to select the middle of the stream, to avoid the outlets of feeders, and to note whether there has been previously a heavy fall of rain or a long drought. When a

sample is required from the source of a spring, it is sometimes necessary to dig a small excavation and allow all sediment to subside before the sample is taken. Well-water should of course be drawn direct from the well.

Different methods of examination require different quantities; ordinarily one Winchester quart will be quite sufficient, but for a complete investigation some analysts require about a gallon. For qualitative analysis, pint stoppered bottles will be found to be large enough, because, should a greater quantity be required at any time, two bottles can be used instead of one.

Section II.—Physical Examination

A portion of the sample collected should be poured, after shaking the bottle, into a good-sized clear glass flask. If the flask is then held in front of a dark-coloured surface, with a good light falling on the side or from above, any suspended impurities will become visible, but care should be taken to discriminate between them and air-bubbles.

Colour and turbidity are best ascertained by pouring the water into a two-foot tube of colourless glass, and placing it upon a porcelain slab or piece of white paper. Another glass of the same dimensions, filled with distilled water, should be placed by its side for comparison. Both samples are then looked through from above, and the difference between them noted. If organic matter is present, the water has usually a tinge of yellow, green, or brown, but mineral substances may give similar indications. Peat and vegetable contaminations impart a brownish tint.

To observe the smell of the water, a portion of it should be poured into a wide-mouthed flask, making it about one-third full, and then shaking it well. If the smell is unpleasant, the water is unfit to drink. Should no smell be detected, the flask should be heated, and the water again shaken, and if there is still no smell a little caustic potash should be added to the warm water. Any unpleasant odour which may now be given off indicates with tolerable

certainty that the water contains organic impurities in considerable quantity. The occurrence of a precipitate on the addition of the caustic potash will at the same time indicate hardness.

Many waters from the clay or lias formations yield distinctly offensive odours owing to the presence of sulphuretted hydrogen, which is given off by the mineral sulphides, such as pyrites, or results from the decomposition of sulphates by organic matter.

A water which is evidently turbid, and which possesses an offensive odour and unpleasant taste, requires no detailed analysis to condemn it;—such a water may at once be pronounced as unfit for domestic use.

Section III.—Microscopical and Biological Examination

In order to collect the sediment the water should be poured into a large conical glass, and allowed to stand for twelve or twenty-four hours. The sediment which collects at the bottom can then be removed by a pipette, and drops can be placed under the microscope without any preparation, while others can be distributed on slides for more extended examination. Some may be dried and examined for bacteria by staining with methyl violet, while by colouring others with carmine and glycerine, any cells may be detected by the red staining of their nuclei which results.

Particles of sand are recognised by their angular shapes and by their not being affected by acids. Particles of clay and marl are amorphous, and are also unaffected by acids. Particles of chalk are amorphous, and are readily dissolved by acids. Dead vegetable matter, such as woody fibre and portions of leaves, and living vegetable matter, consisting of confervoid growths, may all be detected in water which cannot be pronounced unwholesome. So also may *diatomaceæ*, *oscillatoriæ*, *volvocina*, and *entomostraca*. Dead animal matters, such as hairs, striped muscular fibre, and epithelium scales; and manufactured matters, such as fibres of cotton,

wool, linen, or silk, are all indicative of pollution of the water with human refuse, and most probably with sewage. Associated with these matters and feeding on them will generally be found *bacteria*, and other micro-organisms, such as *infusoria* and *amœbæ;* and indeed it may be said generally that the presence of these lowest organisms should always be regarded with suspicion. Microscopical examination, however, is only valuable in so far as it reveals the various kinds of suspended matters and the indications to which they point; it gives no direct information concerning the presence of organic impurities.

Nor can it yet be said that much practical value has resulted from the bacteriological examination of waters, except in respect to the efficiency of filtration. Although various methods are followed in conducting this examination, they all of course depend on the cultivation of the micro-organisms which may be present in the water in carefully sterilised nutrient gelatine.

Section IV.—Chemical Examination

This may be either qualitative or quantitative. For ordinary purposes, as, for example, in the discharge of a medical officer of health's duties in rural districts, a qualitative examination, if judiciously conducted, will be found to be quite sufficient to enable him to give a reliable opinion as to whether a water is fit for use or not in a great many instances, provided the water is not specifically polluted. But in all cases in which qualitative tests indicate that a water is doubtful or suspicious, and in cases which are likely to lead to magisterial proceedings, it is necessary to submit the sample to a quantitative analysis more or less complete. A quantitative analysis is also required in the examination of public supplies, and in the case of any proposed new public supply it should be thorough in all its details.

After noting the various indications obtained from the physical examination previously described, and taking care that all test-tubes, test-glasses, measures, and the like are

thoroughly clean and conveniently arranged, the qualitative testing of one or more samples may be readily conducted as follows :—

1. *Qualitative Examination*

(1) *Ammonia.*—Fill an ordinary test-tube of about 1 oz. in capacity nearly full with the water to be examined, and then add a few drops of the Nessler reagent. If a yellow or brown colour, or a brownish precipitate, be produced, the water contains ammoniacal salts. As a rule, this should be regarded as a very suspicious circumstance, and should the coloration be well marked, it is almost sufficient of itself to condemn the water for drinking purposes. A milky or curdy-looking precipitate will also indicate that the water is hard. If the precipitate is excessive, it masks, to a certain extent, the colour indicative of the test, in which case it is advisable to take a fresh sample in another test-tube, add a few drops of a strong solution of caustic potash, and after the precipitate which is thus formed subsides, add the Nessler reagent.

(2) *Nitrites.*—Fill an average-sized test-glass about three parts full of the water to be examined, then add 5 minims of pure sulphuric acid and 5 minims of a solution of potassic-iodide (5 grains to 1 oz. distilled water), and afterwards pour in a small quantity of freshly-prepared starch solution. The solution is best prepared by rubbing one part of starch with 20 parts of distilled water. The liquid is then filtered, boiled, and, after being allowed to stand for twenty-four hours, the clear liquid is syphoned off. Or a potassic-iodide and starch solution may be made by boiling 20 grammes of starch intimately mixed with half a litre of distilled water, filtering when cold, and adding 1 gramme of potassic-iodide. A blue tint indicates nitrites, and should the colour be at all deep the water is unsafe.

The meta-phenylene diamine test is still more delicate, but it takes twenty minutes before the full development of colouring is reached. The solution is made by dissolving

5 grammes of meta-phenylene diamine in 100 c.c. of water, and slightly acidifying with sulphuric acid. 1 c.c. of the reagent added to 50 c.c. of the water yields a pale yellow tint, increasing to a deep orange red according to the quantity of nitrites present.

(3) *Nitrates.*—A ready method of testing for nitrates is that known as Horsley's test, of which the following modification has been proposed by Dr. Bond of Gloucester:—Put 20 minims of pure sulphuric acid into a very small test-tube, then add 10 minims of the water to be examined, and afterwards drop in carefully 1 drop of a solution of pyrogallic acid (10 grains to 1 oz. distilled water acidulated with 2 drops of sulphuric acid). A pink zone, or sometimes a delicate blue zone changing into a dark amethyst tint, and from that into a brown tint, indicates nitrates. When shaken up, the greater part of this coloration may disappear for a time, but it gradually returns, and after the mixture has stood for a few hours a permanent tint is developed.

Another test for nitrates is that known as the brucine test. The solution of brucine is made by dissolving 1 gramme of brucine in 1 litre distilled water. An equal portion of this should be mixed with the water to be examined in a test-glass, and pure sulphuric acid should be poured gently down to form a layer at the bottom, when, if nitric acid be present, a marked pink and yellow zone is developed.

The process of nitrification by which nitrogenous matter in water or in the soil is oxidised with formation of nitrates is due in great measure to the action of microbes. Nitrites, as a rule, point to more recent pollution than can be inferred from the presence of nitrates, because nitrous acid indicates the presence of organic matter undergoing change. Indeed, the detection of nitrates in a water derived from a deep well is no evidence of recent sewage contamination, because, as in the chalk formation, they may be derived from the strata through which the water passes, but in surface or shallow well waters their presence may fairly be regarded as a suspicious circumstance.

(4) *Chlorides.*—The amount of chlorine in water can be determined so quickly by a simple volumetric method, which will be subsequently described, that those who are provided with the test-solution of nitrate of silver should always adopt this method; but to those who have not this test-solution the following method is recommended:—Acidulate a little of the water in a test-glass with a few drops of dilute nitric acid, and add in excess a solution of nitrate of silver. Four grains per gallon of sodium chloride give a turbidity; 10 grains a slight precipitate; and 20 grains a considerable precipitate, soluble in ammonia. A good water should only yield a slight haziness. If there is a distinct precipitate, it shows that the water is derived from a formation rich in salt, such as the new red sandstone, that it is brackish if on the sea-coast, or that it has been contaminated with sewage. In the first two cases there will be a large amount of mineral solids, and therefore, in the case of a soft water, any excess of chlorides would point to sewage contamination, especially if the precipitate is of a dark colour.

In most waters the only chlorine present is chloride of sodium or common salt, and as urine contains about one per cent of salt, any sewage-polluted water will contain a varying ratio of chlorine above its normal amount. Hence in respect to shallow well waters it is of the utmost importance that the normal amount of chlorine contained in the subsoil water should be known before any legitimate inference can be drawn from the chlorides found to be present. They are no indication of impurity *per se.*

(5) *Phosphates.*—So many waters, otherwise fit for domestic use, contain traces of phosphates, that the majority of analysts ignore their presence. The usual method of testing is as follows:—Evaporate the water to about $\frac{1}{50}$ of its bulk in a porcelain dish, acidulate with nitric acid, then add double the quantity of a solution of ammonium molybdate. If phosphates are present a well-marked yellow colour is developed, and on standing, a precipitate.

(6) *Sulphates.*—Acidulate with a few drops of hydro-

chloric acid, and add a solution of barium chloride. One and a half grains per gallon will yield no haziness until after standing, but 3 grains will yield an immediate haze.

(7) *Sulphides.*—Add a few drops of dilute hydrochloric acid, when hydrogen sulphide is evolved which can be detected by its odour, or if moist acetate of lead paper is held over the mouth of the tube it will turn black. If a solution of sodium nitro-prusside is added, a violet purple colour indicates that the sulphides are alkaline.

(8) *Lime.*—Add a solution of ammonium oxalate. Six grains per gallon will yield a turbidity; 16 grains a distinct precipitate; and 30 grains a large precipitate, soluble in nitric acid.

(9) *Magnesia.*—Filter water after addition of ammonium oxalate to remove lime, then add a few drops of sodium phosphate solution, ammonium chloride solution, and excess of pure ammonia. In twenty-four hours a precipitate of the triple phosphate forms either in the shape of prisms or in feathery crystals.

(10) *Iron.*—Add solution of ammonium sulphide. A black colour or precipitate disappearing on addition of dilute acid will indicate the presence of iron. A mixture of potassium-ferro and ferri-cyanide strikes a blue colour.

(11) *Lead.*—Ammonium sulphide yields a black colour not removable by hydrochloric acid. Small crystals of potassium bichromate give a turbidity.

(12) *Copper.*—Copper yields the same reactions as lead with ammonium sulphide, but may be distinguished from lead by the ferro-cyanide test, which when added to a water with a trace of copper yields a brown colour, or if more be present, a brownish precipitate.

(13) *Zinc.*—Although copper is rarely present in water, zinc is readily dissolved from galvanised iron water-pipes, which are sometimes used for small supplies. Potassium ferro-cyanide, added to a filtered and acidulated water containing zinc, yields a white haziness or heavy precipitate, according to the amount present.

(14) *Organic matter.*—In the absence of iron, nitrites, and sulphides, a solution of potassium permanganate will give indications of the presence of organic matter, but the test is not very reliable. Rapid decoloration would point to the presence of organic impurities of animal origin, while slower decoloration would indicate the presence of vegetable impurities.

If the medical officer of health is well acquainted with the geological characteristics of the well-waters in his district, a very few of these tests, such as the tests for free ammonia, nitrites, and chlorides, together with the indications given by the physical appearances, will enable him in a great many instances to give a reliable opinion, and he can examine several samples in a comparatively short space of time; but, in order to conduct the examination systematically, he ought to arrange the test-tubes or glasses in separate sets, and number them according to the samples. These, it is presumed, are all derived from surface or shallow well waters, and the following indications will enable him to decide as to whether the water is fit for use or not, or whether it is of doubtful purity, in which case it should be submitted to a quantitative analysis:—

If the water contains a considerable amount of sediment, and is found when decanted off, or filtered, to show little or no traces of ammonia, nitrites, or chlorides, it shows that it is fit for use, but the well requires cleaning out; or, should the well be a tube well, that it ought to be filtered. If the sediment is flocculent and dirty-looking, it will generally be found that the water is polluted in other respects, and an order should be given that the well should be opened, examined, and cleaned out, and any ascertained source of pollution removed. In towns or villages where there is a public water-supply, and the premises are within easy reach of a water-main, there should be no hesitation in requiring the well to be closed; or if the ground is so saturated with filth from leaky drains or cess-pits that it is hopeless to expect that any alterations can ensure subsequent safety, an order to close the well should still be insisted on. But

supposing the water is tolerably clear, or quite clear, what are the inferences to be drawn from the qualitative examination? If there is distinct coloration on the addition of the Nessler reagent, but very little precipitate, and with no distinct indications of either nitrites, nitrates, or chlorides, it shows that the water is a soft water and fit for use, and that the ammonia is either derived from rain-water or is probably of vegetable origin. If ammonia, nitrites, and chlorides in excess are all present, the water is polluted and unfit for use. A water with no great excess of chlorides, and which yields a large flocculent precipitate on the addition of the Nessler reagent, but does not become tinted, and gives no indication of the presence of nitrites, nitrates, or organic matter, is a hard water, but otherwise may be fit for use. Should a water contain nitrates and traces of nitrites, but give no distinct indication of ammonia or chlorides, it may be considered fit for use. If nitrites and chlorides are both present in any excess, the water should be regarded as a very suspicious water, and be submitted to a more careful examination, even though the Nessler reagent should produce no distinct coloration. But it should always be remembered that chemical analysis, however complete, can only indicate danger when palpably present; it is powerless to indicate any standard of safety when a water becomes specifically polluted.

In giving instructions as to what action should be taken when a sample of well-water is found to be polluted, it is always advisable, when there is no public supply within reach, to recommend that the well should be opened and examined. The pollution may arise from want of cleansing, or from leakage from a drain, cess-pool, or farm-yard, and it will depend upon the special circumstances of the case as to whether cleansing and removal of the source of pollution will suffice, or whether the well should be closed altogether, and a new one sunk in some other suitable place where there is no risk of pollution. It is evident, therefore, that detailed information with regard to the situation and surroundings of a polluted well is of the

utmost importance in advising as to what particular steps should be taken.

It may be noted here that Dr. Thresh, County Medical Officer of Health for Essex, has recently published a small brochure on "A Simple Method of Water Analysis" which appears to be very serviceable for qualitative analysis. The reagents, which have been prepared by Messrs. Burroughs, Wellcome and Co., from Dr. Thresh's formulæ, consist of soloids and capsules of known strength and purity. The process has been thoroughly tested in the laboratory, and the results, when compared with those obtained by more elaborate processes, have been found to be accurate and reliable.

2. *Quantitative Analysis*

With the exception of proposed new public supplies, which should in all cases be submitted to a very minute analysis, the only points which require determination in an ordinary quantitative analysis are the total solids, the hardness, the chlorides, and the organic matter as represented by the free and albuminoid ammonia. If deemed necessary, additional evidence as regards the quality of a water will be obtained by determining the amount of oxygen absorbed, the amount of nitrogen existing as nitrates and nitrites, and, qualitatively, the amount of phosphates.

(1) *Total Solids.*—The amount of total solids is ascertained by evaporating a known portion of the water to be examined to dryness. Into a platinum dish, which has been carefully cleaned, dried, and weighed, pour 70 c.c. of the sample of water; place the dish over a ring burner, and evaporate down to a small quantity, taking care that there is no simmering or boiling, then evaporate to dryness in a water-bath, wipe the dish externally, and weigh. The difference between the two weighings gives the weight of the residue yielded by 70 c.c. of water. Seventy c.c. are taken because each milligramme of residue counts for one

grain of total residue in a gallon of water, inasmuch as a gallon of water weighs 70,000 grains, and 70 c.c. weigh 70,000 milligrammes.

If the operator has a very delicate balance, and has had some experience in chemical manipulation, 25 c.c. of the water to be examined will usually be found sufficient, provided the water contains an average amount of solids in solution; but in that case the result in milligrammes must be multiplied by 2·8 (4 × ·7) in order to obtain the total amount of residue in grains per gallon. Thus, to take the following example:—

Weight of dish . . .	24·286 grammes.
„ dish and residue .	24·295 „
Therefore weight of residue =	·009

But ·009 grammes are 9 milligrammes, and multiplying this number by 2·8 gives 25·2 grains as the amount of solid residue in a gallon of the water examined. If 100 c.c. are taken, the multiple will of course be ·7. The times occupied in the evaporation average about two hours for the 100 c.c., an hour and a quarter for the 70 c.c., and about half-an-hour when only 25 c.c., are evaporated. In drying the residue, the dish should be put into a hot-air bath, then allowed to cool, and weighed promptly afterwards to avoid deliquescence of the salts. As soft waters yield a very insignificant residue, at least a quarter of a litre would be required for evaporation.

The total solid residue consists for the most part of mineral matter, and in many waters this is composed chiefly of carbonate of lime. It is difficult to fix the maximum amount of permissible solid residue in drinking water. In public supplies it certainly ought not, if possible, to exceed 30 grains per gallon, but many usable well-waters are found to contain double this amount.

The following are examples of the amount of solids in different waters:—

	Grains per Gallon.
Loch Katrine	2·30
Vyrnwy Lake	3·18
London Thames Companies	21·66
Rochdale spring	25·93
Norwich artesian well	26·70

If a complete quantitative analysis of the saline constituents is required, a much larger quantity of water must be evaporated, but the presence and relative amount of the more important constituents may be approximately determined by some of the qualitative tests just described.

It is seldom, however, that these subsidiary tests are required. A more important indication is obtained by incinerating the residue over a flame, when, if blackening occurs, the presence of organic impurities may be inferred, and should a bad smell be given off at the same time, it is almost certain to be derived from impurities of animal origin. The dish may be again cooled and weighed, when the loss of weight is returned as loss on ignition, and the final residue may be used for the qualitative determination of phosphates when that is deemed necessary.

(2) *Hardness.*—It has already been pointed out that a water is hard or soft according to the amount of solid residue which it contains. Thus a water which contains only 3 to 4 grains of residue, such as the Loch Katrine water, is an exceedingly soft water; a water containing 8 to 10 grains is a moderately soft water; while those which contain 20 grains and upwards are hard waters. For purely sanitary purposes, therefore, the determination of the hardness is seldom required, if the total solid residue has been ascertained. The hardness of a water is due to the presence of earthy salts, generally carbonate of lime and sulphate of lime and magnesia. The former is deposited on boiling, and is represented by what is called the removable hardness, while the latter, inasmuch as it is not affected by boiling, is called the permanent hardness. The *rationale* of the process, as first explained by the late Professor Clark, will be understood when it is remembered that if an alkaline oleate, such as soap, is mixed with pure water, a lather

is formed almost immediately; but if salts of lime, magnesia, baryta, iron, or alumina are present, oleates of these bases are formed, and no lather is given until the earthy bases are thrown down. As the soap will combine in equivalent proportions with these bases, it is only necessary to make the solution of soap of known strength by standardising it with a known quantity, say of chloride of calcium, to be able to determine the amount of lime or its equivalent of other salts in the water—so much soap required before a lather is produced represents so many degrees of hardness.

A ready method of making the soap test, and one which gives fairly accurate results, is to dissolve 10 grammes of green Castile soap in a litre of weak alcohol of about 35 per cent. One c.c. of this solution precipitates one milligramme of carbonate of lime. The mode of employing the test is as follows:—

Into a clear glass-stoppered bottle, capable of holding about 250 c.c., put 70 c.c. of the water. Add slowly from a burette the standard soap solution, and shake well until a persistent lather is formed, when the bottle is laid on its side noting accurately the amount of solution used. Each c.c. of the solution consumed indicates 1 grain of carbonate of lime, or its equivalent, in a gallon of water. If, after adding 17 c.c. of the solution, no lather is formed, add 70 c.c. of distilled water and mix, and continue the addition of the soap solution. Should no lather be formed until other 17 c.c. are consumed, other 70 c.c. of distilled water must be added, but in making the calculation for hardness 1 must be deducted from the number of c.c. of soap solution used for each 70 c.c. of water which have been added, and this deduction is necessary because 70 c.c. of distilled water would themselves neutralise about 1 c.c. of soap test. Suppose, for example, that 18 c.c. of soap solution have been required, then 1 must be deducted for the 70 c.c. of distilled water which were added, and the hardness of the sample in question is put down as 17 degrees. In other words, the total soap-destroying power of the water is

equivalent to 17 grains of carbonate of lime per gallon. The permanent hardness is obtained by boiling 70 c.c. of the water for about an hour, and making up the loss by evaporation with distilled water. During boiling, the bicarbonate of lime is decomposed and the carbonate deposited, and thus the water becomes softer. After allowing to cool and filtering, the permanent hardness is determined in the same way as the total hardness, and the difference between these two, as already stated, is the removable hardness.

According to Wanklyn's method, the degrees of hardness represent "the potential carbonate of lime," and in translating them into Clark's degrees it is necessary to deduct 1. Thus, in the above example, the degrees of hardness, according to Clark's standard, would be 16.

Altogether, the importance of this test has been greatly over-estimated, and it is seldom that the medical officer of health will deem it necessary to employ it.

(3) *Chlorides.*—The estimation of chlorine as chlorides in water can be readily determined volumetrically by means of chromate of potash and a standard solution of nitrate of silver. This solution is prepared by dissolving 4·79 grammes of dry nitrate of silver in a litre of distilled water. As chromate of silver is soluble in acids, it is necessary that the nitrate of silver used should be neutral. Each c.c. of this solution precipitates 1 milligramme of chlorine. Seventy c.c. of the water to be examined are put into a beaker or evaporating dish, and a small crystal of pure chromate of potash, or a few drops of a strong solution of this salt, added, sufficient in either case to produce a distinct yellow tint. The standard solution is then dropped carefully in from a graduated pipette or burette, and directly the first faint tinge of red is discernible and remains permanent on stirring, the whole of the chlorine is precipitated, and chromate of silver, which is a dark red, is formed. The number of c.c. of the solution used before this red tinge is obtained represents the number of grains of chlorine per gallon of water. If, for example, 3·5 c.c. of

this solution have been required, the water contains 3·5 grains of chlorine per gallon.

The following are examples of the amount of chlorine in different waters :—

	Grains per Gallon.
Thames at Kew	·847
Thames at London Bridge	4·452
Vyrnwy Lake	1·0
Polluted well at Rugby	7·5

The indications afforded by the chlorine test have previously been dwelt upon in the remarks on the qualitative examination of water, and they need not therefore be further referred to here.

(4) *Ammonia and Organic Matter.*—Of the two rival methods of estimating the organic matter in water—namely, that of Frankland and Armstrong, and that devised by Wanklyn, Chapman, and Smith—there is a general concurrence of opinion that the latter is especially suited for the medical officer of health, because it is easy of application, and, so far as chemical analysis can at present indicate, yields sufficiently accurate results for ordinary hygienic purposes. Frankland's process of estimating the organic carbon and nitrogen is a method of no small difficulty, and in the hands of any but an experienced chemist the risk of experimental error is very considerable. What is known as the *Ammonia process,* therefore, will be the process described here. The *rationale* of the process depends upon the fact that vague and indefinite nitrogenous bodies can be converted into a definite compound, namely, ammonia, and that in this way they can be estimated and expressed as ammonia. Owing to the excessive minuteness of the quantities of nitrogenous compounds which distinguish between a good and a bad water, it is convenient to adopt a much finer scale of measurement than is requisite for the saline constituents ; and the amount of ammonia is accordingly expressed by milligrammes per litre, or so many parts in a million. The reagents which are employed are the Nessler test, a standard solution of ammonia, a saturated

solution of carbonate of soda, and a solution of potassium permanganate and caustic potash.

a. Nessler Test.—Dissolve, by heating, 35 grammes of iodide of potassium and 13 grammes of corrosive sublimate in about half a litre of distilled water, and afterwards add gradually a cold saturated solution of corrosive sublimate, and keep stirring until the red colour produced begins to be permanent. Then add 160 grammes of caustic potash dissolved in about 200 c.c. of distilled water, and dilute with sufficient water to bring the whole up to a litre. To render the test sensitive, add about 20 more c.c. of the saturated solution of corrosive sublimate, and allow it to stand, in a stoppered bottle, until the precipitate has subsided. The clear liquid may now be decanted and kept in a tightly stoppered stock bottle ready for use.

b. Standard Solution of Ammonia. — Dissolve 3·15 grammes of crystallised sal-ammoniac or ammonium chloride in one litre of distilled water. Every c.c. of this solution contains one milligramme of ammonia. This is termed the strong solution, and is the most convenient to keep. To prepare the dilute solution, put 5 c.c. of the strong solution into a half-litre flask, and fill up with distilled water. This is the standard solution of ammonia, and contains 0·01 milligramme of ammonia in 1 c.c. of water.

c. The Saturated Solution of Carbonate of Soda may be prepared by boiling an excess of the common carbonate in distilled water. About 10 c.c. of this solution is the proper quantity to use, or instead of the solution about 1 gramme of the dry carbonate of soda, which has just been ignited, may be employed. The carbonate of soda is used in order that the free ammonia may be more easily dispelled on distillation.

d. The Permanganate of Potash and Caustic Potash Solution is prepared as follows:—Dissolve 8 grammes of crystallised permanganate of potash and 200 grammes of solid caustic potash in one litre of distilled water. Boil the solution for some time to free it from all traces of ammonia, and afterwards replace the water lost by evapora-

tion by adding sufficient distilled water to make up the litre.

The distilled water which is used to make up the various solutions may be obtained of sufficient purity from any common drinking water, if care is taken to reject the first portions of distillate, and the distillation is not pushed too far. It should always be carefully tested before being used, and so chemically pure that in 100 c.c. there ought not to be 0·005 milligramme of ammonia.

The following is a list of the apparatus required for the process:—A stoppered retort, capable of holding at least one litre; a Liebig's condenser; a good-sized Bunsen's lamp or burner; a retort-holder; about half a dozen Nessler glasses made of white glass, and with a mark at 50 c.c.; a half-litre flask; a graduated burette marked into c.c., to measure off the standard solution of ammonia; and a pipette marked to hold 2 c.c. It need hardly be said that the greatest care must be taken to have the whole of the apparatus thoroughly clean before it is used. Glass vessels should first be washed out with a little strong hydrochloric or sulphuric acid, and afterwards with pure water.

The analysis itself is thus performed:—After mounting the retort on the holder, and properly connecting it with the Liebig's condenser, half a litre of the water to be examined is poured into it, and 10 c.c. of the solution of carbonate of soda added. The Bunsen lamp is now lighted, the retort thrust well down into the flame, and 50 c.c. are distilled over into a Nessler glass, and *Nesslerised*. Then distil over 150 c.c. and throw this distillate away. This amount is thrown away because it has been found that the first distillate contains exactly three-fourths of the free ammonia present in the water, and it is therefore a waste of labour to Nesslerise the whole of the four 50 c.c. distilled over. There are now 300 c.c. left in the retort, and in order to liberate the "albuminoid ammonia," 50 c.c. of the permanganate of potash and caustic potash solution are poured into the retort by means of a wide funnel. To prevent bumping, which is very liable to occur with a bad water, the retort

should be gently shaken, so as to give the mixture a wavy motion. The distillation is then continued, and three separate distillates, each of 50 c.c., taken and Nesslerised.

What is called Nesslerising is the process of ascertaining the strength of a dilute solution of ammonia by means of the Nessler reagent. Let the first distillate of 50 c.c. be taken as an illustration. To this distillate, which is contained in one of the Nessler glasses, 2 c.c. of the Nessler reagent are added by means of the 2 c.c. pipette, which also serves as a convenient stirrer. If, after stirring and waiting about a couple of minutes, the liquid assumes a rich deep brown, it contains much ammonia; if even a distinct brown tint is developed, it contains a considerable quantity of ammonia; but if it remain colourless, it does not contain so much as ·005 milligramme. When only a light-yellowish tint is produced, the amount of ammonia present is comparatively small. In any case, however, the exact amount is determined by comparing with a known solution of ammonia. The depth of tint in the distillate is imitated by mixing, in a Nessler glass, more or less of the dilute standard of ammonia contained in the burette with distilled water, and filling up to 50 c.c., and then adding 2 c.c. of the Nessler reagent. If, after stirring and waiting two or three minutes, the tint developed in the artificially prepared solution is too dark or too light, it is necessary to make another artificial solution of less or greater strength, as the case may be. With a little practice it is easy to approximate very closely to the exact amount of the standard solution of ammonia which will be required to produce a tint on the addition of 2 c.c. of the Nessler reagent, which will harmonise completely with the tint of the distillate. In order to be able to compare the tints accurately, the Nessler glasses should be placed on a white porcelain slab or sheet of white paper. The number of c.c. of the standard solution of ammonia, which on the addition of the Nessler reagent were required to reproduce the exact tint given by the distillate, are noted, and the amount of "free ammonia" contained in the sample of water can then be readily calculated.

The other three distillates which contain the albuminoid ammonia are Nesslerised in the same way, and the amount of the standard solution of ammonia, which was required to imitate the tints in each case, is also noted. These several amounts added together represent the total "albuminoid ammonia" contained in half a litre of the water. It has already been pointed out that the first 50 c.c. which were distilled over contain three-fourths of the whole of the "free ammonia," and that therefore the next 150 c.c. distilled over may be thrown away. It was formerly the practice of Mr. Wanklyn to Nesslerise the whole four 50 c.c. to obtain the total of the free ammonia; but the amount contained in the first distillate was found to bear such a constant ratio to the amount contained in the other three distillates, namely, as 3 to 1, that it becomes a needless expenditure of labour to Nesslerise them. The rule, therefore, is to add one-third to the amount of ammonia found in the first distillate, in order to obtain the whole of the free ammonia.

Remembering now that each c.c. of the standard solution contains ·01 milligramme of ammonia, the calculation in any given case becomes very simple. For example, suppose the amount of dilute standard solution of ammonia required to match the tint in each case to be as follows:—

Free ammonia distillate		2 c.c.
Albuminoid ammonia	1st distillate	5 „
	2nd „	2·5 „
	3rd „	·5 „

then we arrive at the following amounts:—

		Milligrammes.
Free ammonia = ·02 + $\frac{·02}{3}$ =		·027
Albuminoid ammonia	1st distillate	·05
	2nd „	·025
	3rd „	·005
Total albuminoid ammonia		·08

But, inasmuch as half a litre of water was taken for analysis, these results must be multiplied by 2 in order to arrive at the amounts per litre, or per million parts. In the above example, therefore, the results would be stated as follows :—

	Parts in a Million, or Milligrammes per Litre.
Free ammonia = ...	·054
Albuminoid ammonia = . . .	·16

In this process of water analysis it will be observed from the above description that ammonia is to be looked for at two stages: firstly, in distilling off with the carbonate of soda solution; and secondly, on distilling off with the alkaline permanganate solution. The first portion of the ammonia is called the "free ammonia," because it is obtained from the decomposition of those organic impurities in water which are of simple constitution, such as the ureal class, as well as the ammonia which may be present as ammonia. The second portions of ammonia are named "albuminoid ammonia," because the ammonia which is given off is derived from the oxidation of those more complex nitrogenous impurities which are closely allied to albumen.

The following are examples of pure, indifferent, and bad, samples of water, as determined by the ammonia process :—

	Free Ammonia, parts per 1,000,000.	Albuminoid Ammonia, parts per 1,000,000.	Quality.	Name of Authority.
Loch Katrine . .	·004	·08	Good	Wanklyn
Water from Kent Company's mains . .	·01	·02	,,	,,
Vyrnwy Lake . .	·05	·04	,,	Brown
Great St. Helen's pump, London	3·75	·18	Bad	Wanklyn

With regard to the inferences which may be deduced concerning the quality of a water as indicated by this method of examination, Mr. Wanklyn has laid down the

following rules in the third edition of his work on water analysis:—"If a water yield ·00 parts of albuminoid ammonia per million, it may be passed as organically pure, despite of much free ammonia and chlorides; and if, indeed, the albuminoid ammonia amount to ·02, or to less than ·05 parts per million, the water belongs to the class of very pure water. When the albuminoid ammonia amounts to ·05, then the proportion of free ammonia becomes an element in the calculation; and I should be inclined to regard with some suspicion a water yielding a considerable quantity of free ammonia, along with ·05 parts of albuminoid ammonia per million. Free ammonia, however, being absent or very small, a water should not be condemned unless the albuminoid ammonia reaches something like ·10 per million. Albuminoid ammonia above ·10 per million begins to be a very suspicious sign; and over ·15 ought to condemn a water absolutely."

But the experiments of Dr. Cory, to which reference is made at the close of this chapter, prove clearly that polluting matter, potent for harm, may be present in water which, according to Wanklyn's analysis, may be passed as organically pure, and hence it is of the utmost importance that the surroundings and possible sources of pollution of a particular supply should always be carefully taken into consideration. No matter what process may be adopted, whether Wanklyn's, Frankland's, or Tidy's, water analysis can only indicate degrees of impurity and danger, not standards of purity and safety.

On the other hand, it must be admitted that there are many surface well waters in country districts containing even more than ·15 parts per million of albuminoid ammonia, and to which no bad effects can be traced, but in these cases it is probable that the ammonia is chiefly derived from vegetable matter. If the quantity of chlorine found in a water is exceedingly small, any excess of albuminoid ammonia would indicate that the nitrogenous matter present is of vegetable and not of animal origin, and therefore comparatively innocuous. At the same time it should

be remembered that there might be the same absence of chlorine if the water becomes polluted from the presence of the body of a dead animal in a well or cistern.

(5) *Nitrogen existing as Nitrates and Nitrites.*—Several processes have been recommended for the estimation of the nitrogen existing in water as nitrates and nitrites, but the one most generally adopted is that known as the copper-zinc process. What is called the copper-zinc couple is best prepared as follows:—Take a piece of pure zinc foil about 2 inches wide and 4 inches long, cleanse thoroughly, then insert into a wide-mouthed stoppered bottle of 250 c.c. capacity, containing sufficient quantity of 3 per cent solution of cupric sulphate to cover the foil. Allow foil to remain in solution until there is a firm, bronze-looking coating of copper deposited, then carefully pour off solution and thoroughly wash, first with pure water by refilling bottle, then empty and wash with the water to be analysed. Empty once more, and finally refill with the water to be examined, add ·5 gramme of pure oxalic acid, and having inserted the stopper, allow it to remain either in the cold for twenty-four hours, or in a water-bath at from 130° to 140° Fahr. for two hours. The oxalic acid is added to expedite the process and to form insoluble salts of calcium and zinc. If the water does not contain any salts of magnesium, either 5 or 10 c.c. of the clear water may be drawn off with a pipette made up to 50 c.c., and Nesslerised at once in the usual way; but if magnesian salts are present it is necessary to draw off 50 c.c., make up to 250 c.c. with pure distilled water, rendered alkaline with pure caustic soda, and distilled until the last distillate of 50 c.c. is free from ammonia.

From the total amount of ammonia contained in the distillates deduct the quantity of ammonia which has been found to exist in the water as free ammonia, and calculate the amount of nitrogen represented by the difference between the two. For example, 70 c.c. of the water after treatment is distilled as above directed.

	Milligrammes of Ammonia.
1st distillate of 50 c.c. yields	·85
2nd " " " . . .	·08
3rd " " " . . .	·01
Total	·94

Now, suppose that the free ammonia found to exist in the water amounts to ·0098 milligramme in 70 c.c., then,

	Milligramme.
·94 – ·0098 =	·9302.

To convert the ammonia into its equivalent of nitrogen the following will be the formula, where N represents nitrogen and NH_3 ammonia :—

$$\frac{NH_3 \times 14}{17} = N,$$

or, in this instance,

$$\frac{·9302 \times 14}{17} = ·766 \text{ milligramme.}$$

But as 70 c.c. of the water were taken for estimating the nitrogen, the resulting milligrammes of nitrogen will represent grains per gallon, or ·766 grains per gallon.

With regard to the amount of nitrogen existing as nitrates and nitrites in different waters, the following data will be useful :—

	Grains per Gallon.
Spring water	·2
London Water Companies	·26
Some wells from the chalk	·6 to ·7

Any water not derived from the chalk formation containing more than ·7 grains of nitrogen per gallon would be regarded as suspicious, while if the amount reached 1·5 the water would be considered dangerous for drinking purposes.

(6) *The Oxygen or Permanganate Process.*—The *rationale* of this process, which is known also as the Forschammer process, consists in estimating the quantity of oxidisable matter contained in a water by the amount of oxygen absorbed.

The reagents required are :—

a. Permanganate Solution.—Dissolve ·395 gramme of pure potassium permanganate in 1 litre of distilled water. Each c.c. contains ·0001 gramme of available oxygen.

b. Potassium Iodide Solution.—Dissolve 1 part of pure potassium iodide in 10 parts of distilled water.

c. Dilute Sulphuric Acid.—One part by volume of pure sulphuric acid is mixed with 3 parts by volume of pure distilled water.

d. Sodium Hyposulphite.—One part of crystallised sodium hyposulphite dissolved in 1000 parts of water. This solution must always be standardised at the time of using, and corrected so that 10 c.c. shall be equivalent to 10 c.c. of the permanganate solution.

e. Starch Water.—One gramme starch mixed with half a litre of distilled water, boiled and filtered.

The process is then conducted as follows :—

Select two securely stoppered bottles of about 500 c.c. capacity, and introduce into each 250 c.c. of the water to be examined, then add to each 10 c.c. of dilute sulphuric acid and 10 c.c. of standard permanganate solution discharged from a suitable burette. Insert the stoppers and place the bottles in a water-bath at 80° Fahr., and maintain that temperature for four hours. Two separate determinations are made, viz. the amount of oxygen absorbed at the end of fifteen minutes, and that absorbed during the whole four hours, each titration being conducted as follows :—At the end of fifteen minutes one bottle is removed from the water-bath, and a few drops of potassium iodide solution are added to remove the pink colour. After thoroughly mixing, the standard sodium hyposulphite solution is then run in until the yellow colour is nearly destroyed, after which a little starch water is added, and the titration continued until the water is colourless.

Example :—At the end of fifteen minutes from the time of adding the 10 c.c. of permanganate solution the bottle is removed from the water-bath, a few drops of potassium iodide solution added, and titrated with hyposulphite solu-

tion. Now, suppose that the amount required is 7·2 c.c., then,

10 c.c. − 7·2 c.c. = 2·8 c.c. of permanganate solution consumed by 250 c.c. of water,
∴ 2·8 c.c. × 4 = 11·2 c.c. of permanganate solution consumed by 1 litre of water ; but
11·2 × ·0001 (co-efficient for oxygen) = ·00112 gramme or 1·12 milligramme of oxygen consumed by 1 litre in fifteen minutes,
= ·0784 grains of oxygen consumed by 1 gallon of the water in fifteen minutes at 80° Fahr.

At the end of four hours the contents of the other bottle are titrated in a similar manner, and the results expressed in the same way.

The inferences to be drawn from this process may be briefly stated as follows :—After four hours the amount of oxygen consumed should not exceed 1·0 milligramme per litre in a good water ; if it exceeds this amount, and is under 1·5, the water is usable ; but if this latter amount is exceeded the water is either suspicious or bad. It is also worthy of note that a bad or suspicious water is found to consume more than three times as much oxygen in the four hours as during fifteen minutes.

In conducting a water analysis it is expedient, if the amount of solids is to be taken, to commence the evaporation for the solids first, then to commence distilling for the ammonia, and while the evaporation and distillation are going on, to determine the amount of chlorides, and the degree of hardness, if that be considered necessary. Afterwards, if deemed advisable, the nitrogen existing as nitrates and nitrites, the amount of oxygen consumed, and the phosphoric acid may be determined. It need hardly be said that a detailed record of the results of every analysis should be kept in a book set apart for that purpose. The form of report or certificate will of course vary according to the number of data and the mode of analysis, but the following hints will indicate generally how it should be drawn up :—

Date of reception of sample, size, and description of bottle or

bottles, how stoppered or sealed, and how labelled. From whom received.

Physical Examination.

Appearance .	(Clear, or slightly turbid, etc.)
Taste . .	(Tasteless, or unpleasant, etc.)
Odour . .	(Odourless, fœtid, etc.)
Deposit . .	(Slight or large, dirty-looking, flocculent, etc.)

Microscopic Examination.

(Sandy particles, vegetable matters, animal matters, vibriones, etc.)

Chemical Examination.

Qualitative results :—

Free ammonia .	(None—traces—large amount.)
Nitrites . .	(None—traces—large amount.)
Nitrates . .	(None—slight traces, etc.)
Sulphates . .	(None—slight traces, etc.)
Metals . .	(None—traces of lead, etc.)

Quantitative results :—

Total solids .	(In grains per gallon.)
Chlorides . .	(In grains per gallon.)
Free ammonia .	(Parts per million.)
Albuminoid ammonia	(Parts per million.)
Nitrogen existing as nitrates and nitrites	(Grains per gallon.)
Oxygen consumed by organic matter	(Grains per gallon.)
Hardness, total .	(In degrees.)
,, permanent	(In degrees.)

Remarks as to whether the water is soft or hard, of good quality and fit for use, or whether it is polluted and unfit for use.

Date of analysis,—signature, etc.

If it be desired to express the results in grains per gallon instead of parts per million, the following formula will indicate the method of calculation :—

100 : 7 : : ·15 (parts per million) : ·0105 (grains per gallon).
(See Appendix.)

Exclusive of the microscopic examination, which is seldom undertaken, an ordinary water analysis giving the total solids, chlorine, and free and albuminoid ammonia may be completed in about an hour and a half, provided, of

course, that the operator is fairly expert at his work, and has all his test and standard solutions prepared beforehand. The busy medical officer of health may obtain most of these solutions, as well as distilled water, from chemists, but he should always make blank experiments to test their purity and quality.

As already stated, any proposed new public supply should be submitted to a full quantitative analysis of its saline and other constituents, and for this purpose samples should be sent to a professed analyst. It should not only be usable, but the best which can be procured within the limits of reasonable expenditure. All waters subjected to filtration should be examined from time to time, to ascertain that the filtering process is carried on efficiently. Any water which gives indications of having become contaminated with animal or other impurities, and which has hitherto been good and wholesome, should be entirely disused until the source of contamination has been discovered and removed.

Concluding Remarks.—Although it must be admitted that the methods of water analysis which are now in use are capable of detecting very minute quantities of organic matter in large volumes of water, it must always be borne in mind, as previously pointed out, that chemical analysis, however complete, is powerless to indicate any standard of safety when a water becomes specifically polluted. The careful experiments conducted by Drs. Cory and Dupré, at the instigation of the Local Government Board, prove clearly that chemistry cannot tell whether a healthy or a diseased body has been the source of any excremental pollution of any particular water. Many of Dr. Cory's observations had special reference to experimental contamination of different waters,—some with healthy stools and some with the stools of enteric fever patients,—and the results not only gave no indication as to whether the polluting matter came from a healthy or diseased body, but failed to indicate the presence of an amount of specifically polluting matter which must have been far in excess of that

which proved so disastrous in the well-known Caterham epidemic. Indeed, in many of the water-borne epidemics of enteric fever investigated by the Medical Department of the Local Government Board, the implicated water-supply was pronounced to be free from sewage contamination and perfectly wholesome, as in the Beverley outbreak, of 1884; the Buckingham outbreak, of 1888; the Tees Valley outbreak, of 1890; the Trent outbreak, of 1893; and the outbreak at Worthing, of the same year. Moreover, in the Tees valley outbreak, and also in the Worthing outbreak, bacteriological examinations of the water, though carried out by eminent bacteriologists, failed to detect the so-called typhoid bacillus, nor in respect to the severe outbreak of cholera in Hamburg in 1892 was the comma bacillus at any time discovered in the imperfectly filtered water of the Elbe, which was known to be polluted with cholera excreta. It is clear, therefore, that bacteriology as well as chemistry often fails to detect serious accidental, or specific pollution.

CHAPTER IX

IMPURE WATER, AND ITS EFFECTS ON PUBLIC HEALTH

ALTHOUGH impure water has long been recognised as one of the most potent causes of disease, it is only of recent years that minute investigation has succeeded in demonstrating the terrible mortality which it inflicts on all classes of the community. It is true that chemical analysis often fails in detecting the special impurities on which the development of certain diseases depends; it is also true that, even when impurities are detected, it is extremely difficult to estimate their exact etiological value; nevertheless, the broad fact remains, and it is founded on evidence of the most conclusive kind, that a vast number of cases of disease are attributable to the use of impure water, and there are good grounds for believing that, as investigations become more frequent and precise, a continually increasing class of such cases will be discovered. It must also be remembered that the effects of impure water, like the effects of impure air, may engender a general impairment of the health, without giving rise to well-pronounced disease.

Water impurities and their effects may be conveniently considered as follows:—Firstly, water rendered impure by an excess of mineral substances; secondly, water rendered impure by the presence of vegetable matter; thirdly, water rendered impure by animal organic matter, or specific pollution.

Section I.—Water rendered impure by an Excess of Mineral Substances

As all potable waters contain a certain amount of mineral matters, it is extremely difficult to decide the quantities of these ingredients which may be present, either singly or collectively, without producing bad effects. This much, however, may be said, that waters of a moderate amount of hardness, provided that the hardness depends chiefly on the presence of calcium carbonate, are not found to be detrimental to health. A water of 8 or 10 degrees of temporary hardness, equivalent to about as many grains per gallon of total mineral solids, may be pronounced good and wholesome, while one of as many degrees of permanent hardness would prove injurious to many persons. Altogether the voluminous evidence collected on this point is very conflicting, but there is a general consensus of opinion, that the total hardness of a good water ought not to exceed 15 degrees, nor the permanent hardness 5; or, in other words, that even in a moderately hard water, calcium carbonate must always greatly exceed the magnesium and calcium sulphates and sodium chloride. Apart from risks of lead-poisoning, soft waters are preferable to hard for cooking, washing, and general domestic use.

The symptoms referable to an excess of hardness, arising from the presence of earthy salts, are mainly of a dyspeptic nature, and an excess of calcium and magnesium sulphates (7 to 10 grains per gallon) has been known to produce diarrhœa.

The special disease, however, which, more than any other, seems intimately connected with the mineral ingredients of water, is goitre. In some parts of England, such as Yorkshire, Derbyshire, Hampshire, and Sussex, it is found to prevail only in those districts where the magnesian limestone formation abounds. But whether lime and magnesian salts, or ferrum sulphide, as has been suggested by M. Saint-Lager, be the active agents in producing the disease, has not yet been rendered quite clear; but it appears certain that

goitre is originated by water-impurities, and that these are of an inorganic and not organic nature.

The latest authorities on the subject believe the impurity to be of a metallic nature, probably some salt of iron, and explain the prevalence of the disease in localities where the magnesian limestone formation prevails, by maintaining that metalliferous earths are always to be found in those districts. In support of this view it must be admitted that in many limestone localities the disease is by no means prevalent, as, for example, in Scotland, Ireland, Norway, and Sweden, where mountain limestone enters largely into the geological formation.

In respect to the prevalence of stone in the bladder and gravel as associated with hard waters, the evidence is likewise very conflicting, and no satisfactory statistical data have yet been obtained.

The effects of minute traces of metallic compounds in drinking-water are as yet comparatively unknown. It is quite possible that the sanitary condition of a district may in some measure depend on impurities of this description, and, as Mr. Wanklyn suggests, that the salutary effect of "change of air" may be partly due to change in the minute metallic impurity in the water of the parts of the country which are visited.

Of the metallic ingredients, the effects of iron and lead have been the most fully ascertained. It would appear that iron, if present in quantities large enough to impart a chalybeate taste to the water, often produces headache, slight dyspepsia, and general *malaise*, while impregnation with lead from leaden cisterns or pipes has frequently been followed by symptoms of lead-poisoning. In the case of the ex-royal family of France, many of whom suffered when at Claremont from this species of water contamination, the amount did not exceed one grain per gallon; indeed, from cases which have since occurred, it seems probable that the habitual use of water containing from one-tenth to one-twentieth of a grain per gallon may be attended with danger. It is only of late years, however, that the pre-

valence of plumbism among users of soft waters, and the severity of the symptoms have assumed prominence. Apart from the severe colic and paralysis characteristic of lead-poisoning, there are other symptoms which have been clearly established as far more common, such as languor, debility, indigestion, constipation, gouty affections, and general debility.

In 1886, numerous cases occurred in many of the large Yorkshire towns, and notably in Sheffield, Huddersfield, and Bradford. These outbreaks led to a Local Government Board inquiry conducted by Mr. W. H. Power, and the late Dr. Barry; while Dr. Barry estimated that in the West Riding alone, 600,000 persons are liable to lead-poisoning by drinking the waters with which they are supplied. As previously pointed out, it seems to be clearly established that the plumbo-solvent properties of soft moorland waters depend upon their acidity, and that this acidity is due to bacterial growth in the peaty water. This was foreshadowed by Mr. Power in his report to the Local Government Board in 1887, and confirmed by the extended experiments which have since been carried out under the direction of the Local Government Board (see Report of Medical Officer 1893).

Section II.—Water rendered impure by Vegetable Matter

Vegetable matter may be present in water either in suspension or in solution. In peaty water, which is characterised by its brownish tint, the dissolved impurities sometimes do not exceed 2 grains per gallon. In the absence of a purer supply, a water of this description cannot be pronounced objectionable, provided that it is not stored in leaden cisterns, and that the supply is constant, though, as in the case of Sheffield, it may become necessary to treat the water so as to deprive it of its plumbo-solvent properties. If stored in open-air ponds or reservoirs it is improved by oxidation and light; and it is further improved by filtration through gravel and sand.

Water containing a considerable amount of vegetable matter, partly in suspension and partly in solution, is decidedly unwholesome. It has been known to produce violent outbreaks of diarrhœa, and since the days of Hippocrates downwards, it has been popularly acknowledged to be productive of ague and other malarious ailments. In this country there are several instances on record that ague has been much lessened in small communities by using well, instead of surface, water; and there is strong presumptive evidence that, apart from the influences attaching to improved drainage, the great decline of this disease throughout many parts of England, where it formerly prevailed, is in some measure due to the use of purer water. The specific microbe to which all forms of malarial disease is attributed has its natural habitat in the soil, and must therefore teem in marshy water, which is often consumed in foreign countries.

Section III.—Water rendered impure by Animal Organic Matter and Specific Pollution

From a sanitary point of view this is by far the most important class of water impurities. The presence of putrescent animal matter, whether it has percolated through the soil from cess-pools or other filth-accumulations into wells, or whether it has been discharged from open sewers into streams and rivers, converts drinking-water into a dangerous poison, fraught with disease and death. It is true that to a certain extent the process of filtration through a porous soil tends to render less hurtful the sewage which dribbles into a well, but after a time this purifying power is lost, the soil becomes sodden, and the sewage enters unchanged. It is also true that, given a sufficiently large stream, a sufficient length of course, and a sufficient length of time, the greater portion of the sewage discharged into a river will become converted into harmless products by oxidation and nitrification. Yet neither process can be trusted, however complete it may appear to be. There is always danger

lurking in a water which is known to be contaminated with animal matter, and more especially when such matter is partly composed of the evacuations of patients suffering from certain specific diseases, such as cholera, or enteric fever.

Leaving out of consideration the question whether animal organic matter in suspension or in solution is the more injurious to health, it would appear that it is the quality rather than the quantity which determines the danger. As already stated, a trace of fæcal matter, especially when undergoing active biological change, may render a public well poisonous, while a stream of sewer gas may contaminate the contents of a cistern, and be the means of prostrating a whole household.

The principal diseases which have been proved to be produced by this class of water impurities are cholera, enteric fever, dysentery, and diarrhœa.

1. *Cholera.*—Although much had been previously written with regard to the etiology and spread of cholera, it was not generally surmised that the disease could be propagated by a polluted water-supply until the late Dr. Snow published the results of his researches in 1849. At first Dr. Snow's views were rejected by some, or questioned by others; but in 1854 there occurred a violent outbreak of cholera in the parish of St. James, Westminster, the causes of which were inquired into by a committee of medical men, whose report fully substantiated Dr. Snow's conclusions. Between the 31st August and the 8th September of that year, as many as 486 fatal cases occurred within an area bounded by a circle whose radius scarcely exceeded 200 yards. On inquiring into the local peculiarities of the epidemic, Dr. Snow found that the sufferers had been in the habit of drinking the water supplied by a pump-well in Broad Street, which had a great reputation for freshness and sweetness. An analysis of the water proved that it was highly charged with animal impurities, and, at Dr. Snow's earnest solicitation, the handle of the pump was removed by order of the vestry on 8th September, to prevent further use of the water. After this the disease gradually subsided,

and ultimately disappeared. It was made manifest by a subsequent examination that the sewage of a neighbouring house had leaked into the well, and it was further ascertained that the evacuations of a patient residing in the house, and who was suffering from diarrhœa, or actual cholera, must have mingled with the sewage immediately before the occurrence of the general outbreak.

The subsequent cholera epidemics in London of 1855 and 1866 afforded equally conclusive evidence of the intimate relations existing between specifically polluted water and the incidence of the disease; indeed the epidemic in East London in 1866 was conclusively traced to the sewage-polluted, and probably specifically-polluted, water of the river Lea, supplied by the East London Water Company. Whether Koch's comma bacillus be regarded as the *causa causans* of the disease or not the severe outbreaks in Hamburg and other parts of the continent in 1892, and numerous localised outbreaks in India and elsewhere, afford conclusive evidence that it is mainly a water-borne disease. It is true that Pettenkofer and others still dispute this view, and maintain that the disease is telluric, or miasmatic; nevertheless, the Hamburg outbreak not only demonstrated that the disease was traceable to the unfiltered polluted waters of the Elbe, but that the neighbouring town of Altona, which was also supplied from the Elbe, practically escaped, because the water was carefully filtered. In Hamburg there were nearly 17,000 attacks and 8000 deaths, the death-rate from cholera amounting to 13·4 per 1000 of the population, while in Altona there were only about 500 cases, and it was believed that at least 400 of these were infected in Hamburg. Even in those parts of India where the disease is endemic, the reports of sanitary officials afford abundant evidence of the intimate relations which subsist between cholera outbursts and specifically polluted water. Indeed, the grossly filthy habits of the natives cause such constant pollution of the water in the tanks from which vast numbers obtain their entire supply, that the disease is always more or less prevalent.

2. *Enteric fever*:—Amongst the numerous local outbreaks which have been investigated by the Medical Inspectors of the Privy Council, and subsequently of the Local Government Board, the following may be noticed, not only as examples of the painstaking and systematic way in which such inquiries should be conducted, but as illustrating the various modes in which the disease may be propagated.

(1) The account of the epidemic at Terling in Essex in 1867, by Dr., now Sir Richard, Thorne, K.C.B., is valuable as showing the effect of a sudden rise of the ground water-level in a village situated on a porous subsoil, obtaining its water-supply from shallow wells, and allowing its excrementitious filth to accumulate in badly constructed privies and manure heaps, or to lie indiscriminately in scattered masses on the surface of the ground. Out of a population of 900, about one-third of the number were attacked with enteric fever within a period of two months, and 41 had died. Some ten days before the outbreak, and after a period of prolonged drought, a sudden great rise in the water-level of the wells was observed to follow a heavy fall of rain and snow; in other words, the shallow unprotected wells sunk in the porous gravel had become converted into so many receptacles for the washings of the filth-sodden soil, and hence the epidemic.—(*Tenth Report of the Medical Officer of the Privy Council.*)

(2) In the beginning of 1873 a severe outbreak of enteric fever occurred in the small town of Sherborne in Dorsetshire, which was investigated by Dr. Blaxall, and is of extreme interest as having been the first outbreak of the kind which was clearly traced to the entrance of sewer air or insuction of fæcal matter into the water-mains. Although the water-supply was intended to be constant, it was ascertained that in December 1872 and January 1873, the water was frequently shut off at a point near the reservoir, and that during the month of February it was shut off every night. It was observed that when the water was turned off, there were certain water-mains up which there was a sudden rush of air immediately the tap was

unscrewed, and as many of the mains communicated directly with closet-pans by means of taps, which were sometimes left open, and which in other instances were broken, there were thus numerous inlets for the entrance of air from the closet-pans into the water-mains. Moreover, if a pan happened to become full of excremental filth, there was the probability of excrement as well as sewer air having been sucked into the mains. In January and February there were about 27 cases of fever in the town, but before the end of April the number altogether had increased to 240, out of a population of 6041. After the first week, during which 73 cases occurred, the water-supply was again made constant, and the epidemic gradually declined.—(Mr. Simon's *Reports*, New Series, No. II.)

(3) Another outbreak investigated by the late Dr. Page, one of the Medical Inspectors of the Local Government Board, occurred in the Houghton-le-Spring Rural Sanitary District in 1889, and was somewhat remarkable, inasmuch as it was associated with a certain amount of a low form of pleuro-pneumonia. So sudden was the outbreak, that between 16th and 24th April as many as 100 cases had cropped up out of a population of 4400, which obtained its water from a particular public supply, the number of cases subsequently mounting up to 258. Although, by exclusion of other possible causes, the water was suspected from the first, chemical analysis did not confirm this opinion; but on more extended investigation at the source of supply, it was discovered that there was a small feeder which entered the well or "staple" at a depth of 45 feet from the surface, and that this showed distinct indications of organic impurity with an amount of chlorides exceeding that found in the water of the well. On looking around for other possible sources of pollution beyond the immediate vicinity of the well, Dr. Page had visited a farmhouse and buildings about three-quarters of a mile from the well. The house and buildings and an adjoining cottage were situated on the magnesian limestone at a height of about 150 feet above the surface of the well, and the drainage from the house

water-closet, the farm buildings, and cottage were conveyed into a tank. Owing to subsidences caused by the colliery workings below, it was found that fissures extending to the surface existed in the locality, and the overflow from the tank disappeared down one of these fissures. To determine whether there was any connection between this fissure and the water-bearing strata supplying the well, Dr. Page had five tons of salt washed down the crevice, when the chlorine in the feeder mounted next day to 15 grains per gallon, and subsequently to 24 grains, clearly proving, to quote the words of Dr. Buchanan, that "there were good grounds for believing that matters polluting a water-service had been carried along three-quarters of a mile in a fissure of magnesian limestone."

(4) The Tees valley epidemic of 1890-91, which really consisted of two outbreaks following close on each other, affords a remarkable instance of the conflicting views which were entertained as to the exciting cause of the disease For while the late Dr. Barry in his painstaking and elaborate report stated it as his conviction that the water-supply obtained from the Tees was gravely implicated,—a conclusion which was endorsed in the strongest terms by the chief of the Medical Department of the Local Government Board, Sir Richard Thorne,—the Royal Commission on the Metropolitan water-supply regarded the evidence as non-proven. Though they refrained from giving any opinion as to the origin of the disease, they stigmatised the suggestion of specific pollution as a startling hypothesis. And yet Dr. Barry proved that in the first outbreak 33 persons were attacked per 10,000 of those using the Tees water, and only 3 among persons supplied with water from other sources; while, during the second outbreak, the rate-attacks were 28 and 1 respectively. Heavy floods, which washed down huge accumulations of filth from rubbish tips, and the outlets of sewers and drains up-stream, had occurred before both outbreaks, and the conditions were such, that with the introduction of the specific organism of enteric fever, and the possible breaking down of the filters of the

water-works, an epidemic outburst could hardly fail to follow. Enteric fever had been more or less endemic in the Tees valley for years back, and though specific pollution could not be actually traced in these two outbreaks, the pollution of the river up-stream was of the grossest. To quote the words of Sir Richard Thorne in commenting on Dr. Barry's report, "Seldom, if ever, has the proof of the relation of the use of water so befouled to wholesale occurrence of typhoid fever been more obvious and patent." And yet, in the face of evidence such as this, and the numerous other outbreaks of river-borne cholera and enteric fever which have been recorded, the Royal Commission came to the conclusion that the Metropolitan water-supply mainly derived from the Thames and the Lea, both of which receive the drainage of thickly populated areas up-stream, are so safeguarded by filtration, that there is practically no risk. That may be the view of the chemist or bacteriologist, possibly because they so often fail to detect specific pollution; but it cannot well be entertained by the sanitarian. Indeed, Koch in his monograph on cholera and typhoid fever, expressly states that "our previous blind trust in water filtration has been considerably weakened, and it will be a question in future whether, in erecting new water-works, it would not be better to select other water in place of river-water."

(5) The severe outbreak of enteric fever which occurred in Worthing in 1893, and which was investigated by Dr. Theodore Thomson, was rendered unique by the complexity of the conditions involved. The town had remained practically free from fever for a long time previously, but following on a first case in April, a sharp outburst of the disease occurred in the first three weeks in May, and before 28th May as many as 268 cases had been notified. Then followed a marked abatement, culminating in an outburst of exceptional magnitude in the early part of July, and with varying fluctuations, the epidemic did not cease till December. In Worthing alone, the number of cases amounted to 1257, with 168 deaths out of a population

of 15,300, but there was also an extension of the outbreak to the suburbs of West Worthing and West Tarring, with a joint population of 2186, where 154 cases occurred. The water-supply of Worthing was derived from three wells sunk in the chalk, and connected together by headings or tunnels; and as the town increased, these works had become surrounded by inhabited houses. In order to augment the supply, a large heading was being driven in the early part of the year, from the bottom of one of the wells, when, on 14th April, there was a sudden inrush of water from a large fissure which was struck. Although suspicion fell on the water-supply when the outburst took place, both chemical analysis and bacterioscopic examination failed to detect any impurities, and, indeed, it was only in the later stage of the epidemic that conclusive evidence was obtained that the water was being fouled, not only by fæcal matter, but by the "specific material" of enteric fever. Detailed investigation went to show that the soil which overlies the chalk to a depth of 20 feet in the neighbourhood of the wells, was liable to sustained pollution by reason of leaky sewers, and that the fissure which was struck on 14th April was actually in communication with the soil in question. To this source of contamination the first outburst of the epidemic was doubtless due, but the precise origin of the specific pollution remained beyond actual proof.

With respect to the outbreak in West Worthing and West Tarring, which did not reach its maximum until a month after the culmination of the Worthing epidemic, Dr. Theodore Thomson came to the conclusion that the evidence did not point to pollution of the water-supply of these suburbs at its source, as in the case of Worthing, because the supply was altogether different, but "to local infection of water in certain of the mains."—(*Report to Local Government Board*, 1893-94.)

Although in these several epidemics, and many others which have been investigated, there was no direct evidence to show how the water became specifically polluted, the

following outbreaks are notable as indicating the precise origin of the specific pollution.

(*a*) In the small village of Lausen in Switzerland there occurred an outbreak of enteric fever in 1871 which proved that even filtration through a considerable tract of porous soil will not purify water which has once been specifically tainted. It was found, when the outbreak was investigated, that all the houses in the village, with the exception of six, were supplied with water by means of wooden pipes from a certain spring, and that the outbreak was confined to the inhabitants who drank this spring water, the other inhabitants, who drank well water, having entirely escaped. That the disease had been introduced by the spring water was made clear by the following facts:—Behind the village there is a hill about 300 feet high, the westerly spur of which extends into a small side valley, and through this valley runs the Furler brook. Connected with this brook there were the latrines of several scattered farmhouses, in one of which four persons had suffered from enteric fever in the months of June and July. Although at first sight it did not seem possible that there could be any connection between these cases and the outbreak at Lausen, it was ascertained that when the meadows in the Furler valley were watered by damming up the brook, the spring increased in amount, and that when they were thus treated in July it yielded a turbid and bad-tasting water. Not long afterwards, namely, on 7th August, 10 inhabitants were attacked, and in nine days more, 57 persons were prostrated with the disease, the number reaching to 130 at the end of October. To prove that the Furler brook could contaminate the spring at Lausen, the experiment was tried of putting common salt into the brook, when it was discovered that the spring water became quite briny.—(*Deutsch. Arch. für Klin. Med.*, 1873.)

(*b*) The outbreak at Over Darwen, which occurred towards the close of 1874, is alike remarkable for its terrible severity and for the thoroughness with which the cause of the outbreak was traced to its origin. According to Dr. Stevens, who was appointed by the Local Government

Board to inquire into and report upon the epidemic, the first case occurred at a house some considerable distance from the town, but not very far distant from the public water-main. The patient, having contracted the disease elsewhere, afterwards came home ill, and died there. On first inquiry it was stated that the water-supply could not by any possibility be polluted by the excreta from this case, but subsequent investigations rendered it only too apparent that here lay the whole cause of the epidemic. It was discovered that the drain of the closet into which the excreta of this patient were thrown crossed the line of the water-main, and though special precautions had been taken by way of cementing and the like to prevent any leakage, it was found that the drain had become choked up, that the cement had given way, and that the contents of the drain were sucked freely, indeed regularly, into the water-main. No doubt the general filthy condition of the town greatly aided in propagating the epidemic after the specific contagium had been distributed by means of the water-supply, but the terrible rapidity with which the disease spread pointed clearly to specifically polluted water as being the prime cause of the epidemic. Out of a population of about 22,000, 2035 people were attacked within a very short period, and of those 104 died.—(*Local Government Board Reports*, 1875.)

(*c*) In the early part of the year 1879 there occurred a severe outbreak of enteric fever at Caterham and Redhill in Surrey, in which within a period of about six weeks there were about 370 cases and 21 deaths. The outbreak was investigated by Sir Richard Thorne, and his report, apart from its painstaking nature, is of special interest, inasmuch as the disease was brought about under conditions which stand alone in the history of such epidemics. Briefly, it was discovered on careful inquiry that the outbreak was traceable to the circumstance that one of the workmen employed about a fortnight previously in driving an adit leading from an old well to a new bore at the Caterham water-works had been suffering from diarrhœa and typhoid

symptoms, and that for several days the diarrhœa was so severe that he was compelled to evacuate in the adit. On the completion of the work, the water thus became specifically polluted, and the distribution of the disease was found to be limited to houses supplied by the Caterham Company.

(*d*) The outbreak in the mining village of Chester-le-Street, investigated by Dr. Maclean Wilson for the Local Government Board, occurred in the winter of 1892-93, and was ascertained by him to be traceable to specific pollution of the water-supply obtained from a small stream which receives either directly or indirectly the sewage of a population of 3500 in or above the intake of the water-works. Out of a population of about 5000, there occurred between October 1892 and the following March, 58 cases and 4 deaths. Three miles above the intake, there was a group of cottages which drained directly into a tributary of the stream, and in these, 4 cases of enteric fever occurred in October, and 10 other attacks followed in January and February of 1893. The water of the Chester-le-Street Company was filtered, but the sand for filtration was derived from the banks of the Wear which above this point receives the "untreated sewage of a large population."—(*Local Government Board Report*, 1893-94.)

The following outbreak merits particular notice on account of its unique character, and as being the first of the kind reported. During the course of the first week in August 1882 Mr. George Fosbroke, now medical officer of health for the County of Worcester, was called upon to investigate an outbreak of enteric fever which had suddenly assumed unusually extended proportions in the town of Evesham and the adjoining neighbourhood. Before the close of September, as many as forty-eight cases had occurred in the borough, and twenty-one in the rural districts, five of the former and three of the latter having proved fatal. The suddenness of the outbreak, widely scattered though many of the cases were, pointed to some common cause; and, after careful inquiry, Mr. Fosbroke discovered that all the patients first attacked had attended

a regatta held at Evesham on 12th July, and further, that they had all frequented a particular meadow adjoining the river Avon. Still more extended inquiry disclosed the fact that all these persons had partaken of "spirits, lemonade, or ices" while on the meadow, and that the water used either for diluting the spirits or manufacturing the lemonade and ices was obtained from a well which was subsequently found to be contaminated with sewage; but whether specifically contaminated was not quite clear, although suspicions strongly pointed in that direction. In any case, there is no doubt that the water from this well used for the manufacture of the lemonade was the cause of the outbreak, and subsequently, by direct or indirect means, affected no less than 113 persons.—(Mr. Fosbroke's *Report* for 1882.)

3. *Diarrhœa and Dysentery.*—In addition to numerous outbreaks of diarrhœa which have been recorded as due to direct sewage contamination, there have been many instances in which the disease has been traced to water contaminated by sewer gases, as when the overflow pipe from a cistern supplying drinking-water is directly connected with a drain or sewer, or when the same cistern which supplies a water-closet also supplies the drinking-water. There is no doubt, however, that, as in the case of contaminated air, the system from long habitude becomes tolerant of polluted water which often produces a marked effect on those who drink it for the first time. The instances of outbreaks of dysentery which have been traced to the presence of animal impurities in drinking-water are so numerous, especially in Eastern countries, that the mere mention of the fact will suffice.

Concluding Remarks.— Although it is very doubtful whether diphtheria, scarlatina, or ulcerated sore-throat can be classed as water-borne diseases, ill-defined forms of fever are often found associated with polluted well-water. Outbreaks of yellow fever in foreign countries have been traced to water polluted by the discharges of patients suffering from the disease, but this is not a common mode of propagation.

Finally, it has to be noted that several of the entozoa find their way into the body through the agency of drinking-

water, as for instance, the *Tænia solium*, *Bothriocephalus latus*, and the *Ascaris lumbricoides*. The last-named, which is known as the *round* worm, I have found to be common in districts where the water-supply is chiefly obtained from shallow dip-wells. There is reason to believe, too, that the *Oxyuris vermicularis* (*thread* worm) has often a water origin. Indeed the embryos or eggs of all of these and other parasites have been found in water, and so may be taken into the stomach when such water is used for drinking purposes. (See Chapter XV.)

CHAPTER X

REMOVAL OF SEWAGE AND HOUSE REFUSE

In all inhabited places it is of the utmost importance to the health of the community that efficient arrangements should be made for the collection and removal of the excrementitious matter thrown off by the bowels and kidneys, the waste waters from houses, and the dry refuse, such as ashes, dust, and refuse food, which keep constantly accumulating. In towns these refuse matters are largely supplemented by the dung and urine of animals, street sweepings, and the waste waters from manufactories. The liquid refuse, to which the term sewage is applied, is removed by a system of drains and sewers; while the collection and removal of dry refuse is included under the term scavenging.

The amount of solid excreta passed by an adult male living on a mixed diet has been estimated at 4 oz. daily, and the amount of urine 50 fluid ounces. In a mixed population, however, the average amount per head, according to the late Professor Parkes, may be stated as $2\frac{1}{2}$ oz. fæces and 40 oz. urine. Both fæces and urine are slightly acid when first passed, and will remain so for some time if they are kept separate, but when they are mixed, as in cess-pools, privies, and sewers, they rapidly undergo decomposition and give rise to the formation of foul and offensive effluvia. The urea in the urine is speedily decomposed into carbonic acid and carbonate of ammonia. The average daily amount of nitrogen in the fæces and urine together, yielded by a mixed population, is 150 grains. This corresponds to about 10 lbs.

of ammonia per annum, six-sevenths of which are contributed by the urine, and only one-seventh by the fæces.

In almost all villages and in many large towns, the human fæces and a certain amount of the urine are collected under what is known as the *conservancy system*,—in pails, dry closets, privies, cess-pools, or ash-pit middens; but in the great majority of towns what is called the *water-carriage system* is adopted, in which the excreta and the urine are removed along with the liquid refuse by means of drains and sewers. Where there is no unusual difficulty in dealing with the sewage at the outfall, there can be no doubt that the water-carriage system of excretal removal is the one best suited for populous localities, for, apart from considerations of cleanliness and convenience, this system possesses the additional advantage of employing the same channels for the removal of excrementitious matters which are required in every locality for the removal of waste waters, and it does away with difficulties attending efficient scavenging which often become very formidable. Indeed it is found that the sewage of non-water-closeted towns is only slightly less foul than the sewage of towns in which the water-carriage system has been adopted in its entirety; and this can be well understood when it is remembered that in addition to the house waste waters, which are highly charged with organic matter from household slops and the grease and dirt from washing, there is the liquid refuse from stables, cowsheds, public urinals, slaughter-houses, manufactories, and all the filth contained in the washings from yards and street surfaces, when there is no separate system of carrying off the storm water. It is clear, therefore, that even though all the solid excreta were disposed of by a system of conservancy and scavenging, drains and sewers are still required for the removal of the liquid refuse, and this refuse is so foul that it cannot be discharged into any river or stream without causing serious pollution unless it is first efficiently purified.

In describing briefly the various methods which have been adopted for the removal of sewage and house refuse,

it will be convenient to discuss the subject under the following sections :—

1. The water-carriage system.
2. Conservancy methods.
3. Methods best suited for rural districts.
4. Public scavenging.

Section I.—The Water-Carriage System

While there is no doubt that the introduction of water-closets greatly increased the dangers attaching to faulty drains and leaky cess-pools, it has also been made abundantly clear that with drains properly constructed, properly ventilated, and kept properly flushed, and with sanitary appliances of approved type, not only may all such dangers be obviated, but health, cleanliness, and convenience can be better secured by the water-carriage system than by any other method of sewage removal. Unfortunately, however, many of the old defects connected with faulty sanitary appliances, ignorant plumbing, and badly-constructed drains, are still so common in towns, and especially in country houses provided with water-closets, that complete sanitary safety is far from being secured. Indeed, it may be said that no house, whether in town or country, in which there is a water-closet, can be considered safe whose drainage and sanitary appliances have not been entirely remodelled within the last fifteen years on approved and scientific principles, and this applies alike to fittings and drains.

1. Sanitary Fittings.—(1) *Water-Closets.*—According to the model bye-laws of the Local Government Board, every water-closet in a house should be built against an outside wall, and be properly lighted and ventilated. The minimum amount of window space enjoined is two feet by one foot, and additional ventilation should be provided by the insertion of at least one air-brick built in the external wall, or "by an air-shaft, or some other effectual method or

appliance." In very many of the older houses, however, the water-closet is situated either in the centre of the house or in out-of-the-way corners where only borrowed light can be obtained, and efficient ventilation becomes next to impossible. Even with every precaution as to interception of the closet drain and attention to other details, a water-closet so situated cannot be used without tainting the air of the house to a certain extent. As regards large houses, public institutions, and dwellings in flats, the best position for the water-closet is in one or more isolated blocks or projections built tower fashion, and abutting against outside

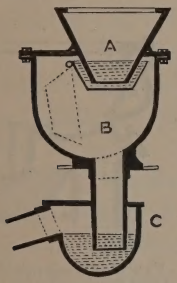


FIG. 9.—Pan closet.
A, Basin; B, container; C, D-trap.

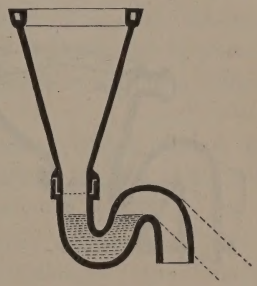


FIG. 10.—Long Hopper Closet.

walls. Efficient cross ventilation can in this way be secured between the closets and the interior of the buildings.

There are now so many kinds of closets well arranged in all their details that it is difficult to say which of them are most to be commended. There are others, again, such as the pan closet with D-trap and container, or the long hopper closet with insufficient flush, which cannot be sufficiently condemned, although both are still very largely used. Indeed, the pan closet (see Fig. 9) is perhaps still more frequently found in the better-class houses than any other kind of closet, although pan and trap soon become coated and exceedingly foul, and the D-trap, which is made of lead, is very often found perforated in places owing to the

chemical action of the excreta and gases on the lead. This kind of closet is never safe, and its use is absolutely prohibited in all new houses wherever the model bye-laws of the Local Government Board have been adopted. The long hopper closet, on the other hand (see Fig. 10), is still very common in the poorer parts of towns. The basin becomes foul owing partly to its faulty form, but mainly to the insufficient water-supply with which it is generally provided, and which swirls round the pan without cleaning it thoroughly.

Generally speaking, the best kinds of water-closets are those which provide for good flushing, and rapid and com-

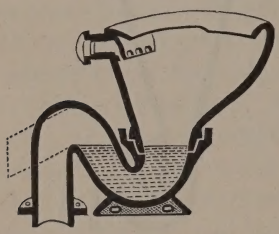


Fig. 11.—Short Hopper or Flush-down Closet.

Fig. 12.—Wash-out Closet. A, After Flush-Chamber; B, Trap Ventilator.

plete removal of the excreta without permitting reflux of foul air. They may be divided into two classes, namely, those in which there is no movable apparatus to retain water in the basin, and those in which a movable apparatus is used for that purpose. Under the first category are included the *short hopper* or *flush-down* closet, and the *wash-out* closet; and, under the second, valve, and plug, closets.

The *short hopper*, *flush-down*, or *deluge closet*, as it is variously called (Fig. 11), is constructed of a short cone of china or earthenware connected beneath with a syphon trap which retains sufficient water to prevent the reflux of air. The back of the basin should be vertical or nearly so, in order that the excreta may drop into the water in the trap, and not upon the sides of the basin, as in the long hopper closet.

The *wash-out closet* (Fig. 12) has a dip in the basin which contains a small quantity of water to receive the excreta. The flush of water from the cistern clears the contents of the basin over the edge into the syphon trap beneath, and the rush ought also to be sufficient to clear the syphon; but as the edge of the basin breaks the force of the water, it is not always easy to keep the syphon perfectly clear, and it soon becomes fouled, even with a flush of three gallons. In order that some water may remain in the dip of the basin, these closets are provided with a small chamber which discharges a certain quantity of water called the "after flush." On the whole, the wash-down or short hopper closet is infinitely preferable to the wash-out, because it can be more effectually flushed, and is therefore less liable to become foul, and because it contains sufficient water to cover the excreta.

What is called the *Dececo closet*, which comes from America, is of the flush-down or short hopper type, has no mechanism, has a deep water receiver and trap for the excreta, and discharges by syphonic action. It does not appear, however, to possess any advantages over the short hopper closets, except that the trap is more efficient.

These different forms of closets should be provided with waste-preventing cisterns holding 2 to 3 gallons of water, and to secure a good strong flush, the supply-pipe should be at least $1\frac{1}{4}$ inch in diameter. Larger cisterns are often used, but on no account should any cistern which supplies water for drinking purposes be used for the direct supply of any closet. Formerly the great majority of long hopper closets were supplied direct from the mains by means of stool-taps; but, as pointed out in the previous chapter, such an arrangement is fraught with the great danger of polluting the water-supply by the entrance of foul air or liquid filth from the closet basins into the mains, and has occasioned numerous outbreaks of typhoid fever. Where there is no house cistern, and the water-supply is constant, these waste-preventing cisterns are especially necessary, and the best form is that with a syphon action. By a very short pull of

the chain the syphon is set in action, and the whole contents of the cistern are discharged into the closet basin. These cisterns are generally made of galvanised iron, and should be silent in action. For this purpose the supply-pipe should discharge near to the bottom of the cistern (Fig. 13).

Many of these closet basins are fitted with a slop tray, or so shaped that they may be used as slop sinks or urinals; and with the exception of a hinged seat, all other woodwork may be dispensed with, and thorough cleanliness of the closet secured.

Another objection which is often raised to flush-out or flush-down closets when situated in the upper floors of houses is the noise made by the rush of water in flushing,

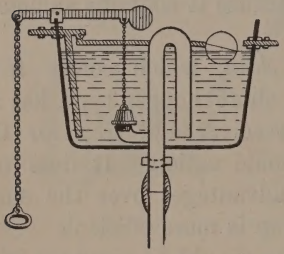


Fig. 13.—Waste-preventing Cistern.

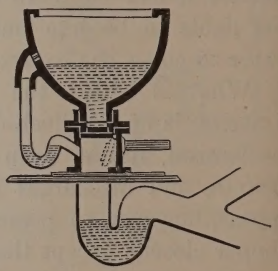


Fig. 14.—Valve-Closet.

and the emptying of the waste-preventing syphon cistern, and on this account many prefer either the *valve closet* or the *plug closet*, both of which are comparatively noiseless when used. Each of these closets should be flushed from a small cistern containing from six to eight gallons, and not from a waste-preventing cistern, as it is necessary to provide for an after-flush.

The *valve closet* (Fig. 14) consists of a semi-spherical basin of china or earthenware, with an opening 3 inches in diameter at the bottom, which is closed by a circular water-tight valve, hinged at one side, where it is connected with the handle. On raising the handle, the valve is depressed into a metal box just large enough to permit the valve to fall back into the upright position, and so permit the

contents of the basin to pass freely into the syphon trap beneath.

In order to secure an after-flush to charge the basin after the closet has been used, some form of valve-regulator, such as the piston-regulator, connected with the supply-pipe from the cistern and worked by the handle, is required. This is so arranged, that after the closet valve is closed, the valve in the supply-pipe is kept open and admits as much water as will sufficiently charge the basin and no more. But in order to permit of an overflow when slops are thrown in, or when there is too much after-flush, an overflow pipe is required, which discharges into the valve-box, and thence into the syphon trap beneath. This overflow pipe is trapped by a syphon bend to prevent the passage of any foul air when the closet contents are discharged.

With this kind of closet the apparatus must rest on a safe-tray, and it is preferable that the syphon trap should also be above the floor level: but the whole of the woodwork which is required to conceal the apparatus, together with the seat, should be made movable, in order that the safe and the other parts under the seat can be readily cleaned.

The *safe-tray*, on which the closet apparatus rests, is made of lead, and is intended to catch any overflow. It should be provided with a syphon-trapped waste-pipe, which must be carried through an outside wall so that it may discharge into the open air. Formerly it used to be the practice to connect this pipe with the filthy D-traps which were so generally used beneath this and the pan closet, thereby permitting a constant current of foul air to enter the house.

The *plug closet* somewhat resembles the wash-out closet, with this exception, that a much larger quantity of water is retained in the basin by means of a plug or plunger, which completely closes the arm leading from the basin to the syphon (see Fig. 12), and which is pulled up when the handle is raised. Both basin and trap are usually manu-

factured in the same piece of china or earthenware, but the closet is open to the serious objection of the plunger becoming fouled by excreta, and its free action impeded by lodgment of pieces of paper. The flushing and cistern arrangements are generally similar to those required for the valve closet, an after-flush being necessary for both alike; but some manufacturers now arrange to flush from a waste-preventing cistern.

(2) *Trough closets.*—For schools, factories, large workshops, public institutions, and groups of houses in crowded courts, trough closets are especially suitable. This form of closet consists of an open trough, rounded at the bottom and made of cast iron specially coated, or glazed earthenware, and is of varying length according to the number of compartments required. The trough should slope slightly towards the drain, and by means of a lip or weir at the lower end, a certain quantity of water is always retained to receive the excreta. The closet is best flushed by a Field's annular syphon flush-tank (Fig. 15), and the frequency of the discharge can be regulated by adjusting the tap supplying the tank or cistern, a small dribble being usually quite sufficient. The tank must be so fixed that the long arm of the syphon is perfectly perpendicular. As the cistern works automatically, effectual flushing is provided without requiring any attention beyond adjusting the tap so that the cistern may discharge itself as often as may be required. The trough should communicate with the drain by means of a syphon trap, and this should be provided with a cleansing cap. Each seat over the trough should be separated by partitions, and these should be provided with doors to secure privacy when the closet is used (see Fig. 16).

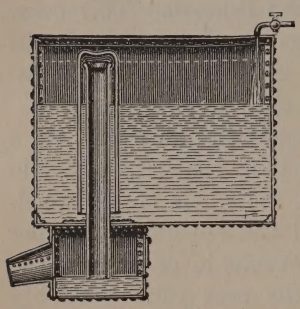


Fig. 15.—Field's Syphon Flush Tank.

Trough closets are admirably adapted for crowded courts, and should be much more extensively used than they are at

present; but to prevent mischievous interference the flush-cistern should be placed in a locked compartment, accessible only to the sanitary inspector or some other responsible officer.

A modification of the trough closet, known as Adam's patent latrine closet, is especially adapted for schools. This is also flushed by an automatic syphon flush-tank, but is so arranged that each seat resembles a separate pedestal closet with hinged lid. The size of the flush-tank is regulated according to the number of pans, and each of these is flushed simultaneously by the syphon discharge into a joint-receiving pipe communicating by means of a ventilating

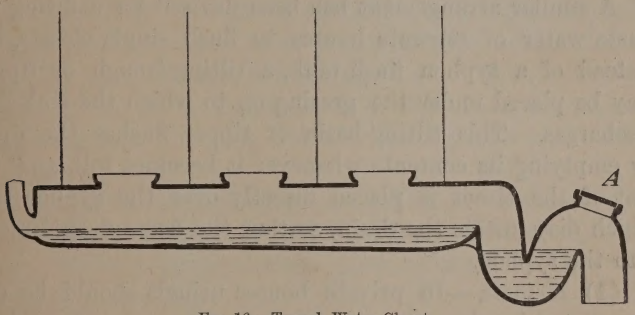


FIG. 16.—Trough Water-Closet.
A, Cleansing Cap.

intercepting trap with the drain. As the receiving pipe in this instance is a close drain instead of an open trough, it is, of course, essential that the trap should be ventilated on the closet side, otherwise the flush tank would not act.

(3) *Slop Closets.*—In many large towns, closets have been constructed on a similar principle, but they are flushed by household slops. The drainage from a row of houses conveys the waste water to an automatic flush-tank or tumbling-basin which is placed at the end of the row farthest from the sewer. From this tank a large pipe-drain leads to the sewer, and separate closets are built over its course. Instead of a pan or basin, these closets have simply a large drain-pipe, which is connected vertically, or sloping slightly backwards, with the drain beneath, the excreta dropping

directly into the receiving drain, and remaining there until the next flush from the tank, or tipper, sweeps them away into the sewer. Between the sewer and the lowest closet, the drain is intercepted by a syphon trap, and at this point a manhole is constructed, which is used in the event of obstruction. Among the best known flush closets may be mentioned Hill's, Fowler's, Day's, and Duckett's; but it is very questionable whether, apart from a slight saving in water-supply, they possess any advantages over trough closets, while, according to Dr. Reid, medical officer of health for Staffordshire, the sewage from them is much more concentrated and offensive than water-closet sewage.

A similar arrangement has been devised for utilising the waste water of separate houses to flush single closets, but instead of a syphon flush-tank, a tilting-trough or tipper, may be placed under the grating on to which the sink-pipe discharges. This tilting-basin or tipper flushes the drain by emptying its contents whenever it becomes full, and the seat of the closet is placed directly over the syphon trap which disconnects the drain, so that the fæces drop directly into the syphon.

(4) *Urinals.*—In private houses urinals should be dispensed with altogether, unless they can be fixed in a perfectly suitable position where a sufficient supply of water can be obtained. The urinal itself should be small, neat, and of pure white porcelain or earthenware. The waste-pipe should be trapped, and if not made to discharge into the soil-pipe, should discharge into a properly ventilated and intercepted drain. The floor, or a portion of it, should be laid with glazed tiles of a light colour.

Public urinals should be made of non-corrosive materials, such as enamelled slate, glazed earthenware, or vitrified fire-clay, and their waste-pipes should discharge over a channel in the floor, which should be properly paved or cemented. They are best flushed by means of automatic flush-tanks.

(5) *Slop-sinks.*—In large houses, slop-sinks are perhaps a greater source of danger than water-closets, unless

proper precautions are taken as regards trapping and ventilation of waste-pipes. Indeed, they should be dispensed with altogether whenever the closet is suitable for the reception of slops. They are generally of conical or square form, and made of glazed china or earthenware with syphon trap beneath. They should be fixed on a leaden tray or safe provided with a waste-pipe discharging into the open air. An open brass grating should be fixed at the bottom of the sink to intercept cloths or other articles. Although it is necessary that the sink should be furnished with means for flushing, it is preferable that it should be flushed from a waste-preventing cistern than by means of a tap, because the latter may be used by servants for filling water-bottles. These should be filled from a tap or taps discharging over a house-maid's trough, which may be conveniently fixed near the sink but on a higher level, so that the waste-pipe may discharge into the sink, but not directly into the waste or soil-pipe.

Pantry or scullery sinks are preferably made of glazed earthenware or fire-clay, but lead-lined sinks are preferred for a butler's pantry, where glass or china is washed up, to prevent breakage.

(6) *Baths and Lavatories.*—The materials and arrangements of these accessories of civilised life are of endless variety, and do not admit of discussion here. But for purposes of cleanliness, the cast-iron bath, well painted, and without any woodwork, is found to answer very well. Such a bath should be placed on a lead tray with waste-pipe discharging into the open air, and the waste-pipe from the bath itself and from any lavatory basin should also be made to discharge in the open in an absolutely pure position. Both the overflow pipe and waste-pipe should be trapped. In ordinary bath-rooms the paper should be varnished.

2. House Drainage.—(1) *Soil-pipes.*—Wherever possible, all soil-pipes should be fixed outside external walls, and carried up full-bore to a point above the eaves and away from sky-lights, windows, or chimneys. The top or outlet should be provided with a copper wire cap instead of

a revolving cowl or ventilator, because the former is liable to become fixed, and the latter may become obstructed owing to birds selecting it for nest-building. The soil-pipe should preferably be fixed a foot away, sideways, from the branch coming through the wall from the closet, and by means of special clips or brackets it should be firmly supported, so as to allow a free space between the pipe and the wall, thus giving access to make secure joints, to paint the pipes when necessary, and to prevent dampness of the wall. The best size for a soil-pipe is 4 inches diameter; and though many plumbers prefer drawn-lead piping as the most suitable material, cast-iron pipes are now generally used on account of their cheapness; but in all cases they should be the same as made for water mains, and coated with Dr. Angus Smith's composition inside and out, and the joints should be made with yarn and molten lead. If drawn-lead piping is used it should weigh at least 7 or 9 lbs. per square foot, according to the height of the building, and the joints should be what are called *wiped* joints, which ensure continuity of bore inside the pipe without any projections. Lead T-pieces are often used to connect the branches from the water-closets with the soil-pipe, even when the soil-pipe is made of iron, but great care in plumbing is required to secure proper jointing, and the joint should never be made in the thickness of the wall. Whether the branch connecting the water-closet with the soil-pipe be of lead or iron, it is essential that the closet-trap should be provided with a flange in order to secure a smooth and firm junction between the two, or a brass collar may be fixed on the end of trap into which the branch pipe can be more securely jointed. Then, again, in jointing the soil-pipe into the house drain, when this consists of earthenware pipes, flanges should be affixed to the soil-pipe so as to grip the cement firmly, and such joints should be always vertical and never horizontal, while the curved pipe receiving the soil-pipe should rest on a bed of concrete.

When several closets discharge into the same soil-pipe, as in lofty houses, or houses built in flats, special provision

must be made to prevent syphonage of the traps of the lower closets when an upper closet is used. This is effected by ventilating the out-go bend of every closet-trap separately into an anti-syphonage pipe carried alongside the soil-pipe from the lowest closet to above the eaves, or it may be joined into the soil-pipe above the highest closet. If, however, the closet-trap is contracted to 3 inches and discharged into a 4-inch soil-pipe, the risk of syphonage is greatly lessened.

(2) *Waste-pipes.*—The waste-pipe from a well-arranged slop sink should be made of drawn lead, 3 inches in diameter, carried outside the wall of the house. If it is connected with the soil-pipe, care should be taken to prevent syphonage ; if not so connected, it should be connected with the drain and carried to above eaves like a soil-pipe.

All other waste-pipes, such as waste-pipes from scullery sinks, baths, etc., should be trapped and made to discharge into the open air on to a grating, or into a ventilating intercepting trap, but in any case they should be thoroughly disconnected from any soil-pipe or drain. Waste-pipes from scullery or pantry sinks should never be larger than $1\frac{1}{2}$ or 2 inches in diameter. According to the model bye-laws of the Local Government Board, all such pipes should be made "to discharge in the open air over a channel leading to a trapped gully-grating at least 18 inches distant. But if the waste-pipes are themselves trapped, as they should be, this open air channel may be dispensed with, or at all events it can be made less unsightly if an arrangement such as Fig. 17 is carried out, in which the channel is covered with a wire screen and the gully is provided with a bucket or receptacle which may be lifted by means of a handle, so that sediment and grease can be really removed. Another arrangement, which complies with the bye-law, is represented by Dr. Sykes's patent disconnecting slipper, manufactured by the Albion Clay Company, Burton-on-Trent, see Fig. 18.

(3) *Traps.*—That too much reliance has been placed by engineers and builders on the efficacy of traps for the ex-

clusion of sewer air, is now a well-established fact. Up till quite recently no adequate provision was made for drain or sewer ventilation, and the consequence was that mechanical

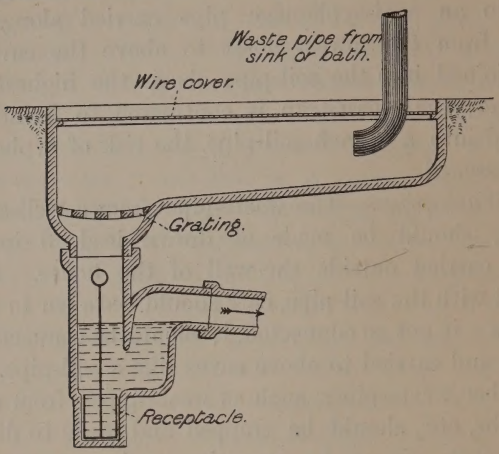


FIG. 17.

ingenuity became taxed to the uttermost to prevent the pent-up sewer gases from forcing their way through the terminals of drains, which for the most part were situated within houses. When hot water is poured down a drain,

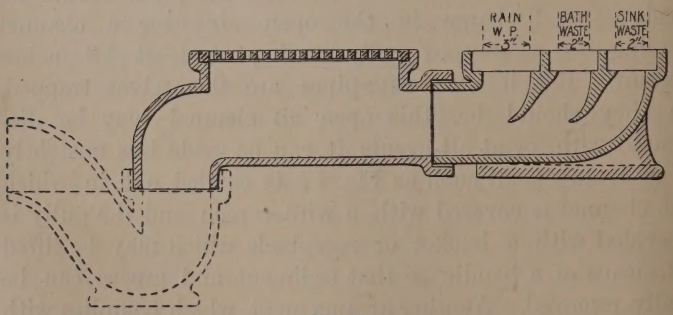


FIG. 18.

or when a sewer becomes suddenly charged with a large volume of water, as after a heavy fall of rain, the forces which are brought to bear within the sewer are far greater than the resisting power of any trap, and the displaced

gases make their escape often at points where they are the most dangerous. There are few traps whose resisting power exceeds that of a column of water an inch and a half in height; indeed, the greater number of them, as, for example, common bell-traps, have only a resisting power of about one quarter of an inch. Besides, it should be remembered that the water in an otherwise very efficient trap will absorb sewer gas on one side and discharge it but little changed on the other. All traps, therefore, should be regarded as at the best useful auxiliaries only, for in no case will they afford protection against the escape of foul air if proper ventilation be neglected.

Although there is an infinite variety of traps, the most

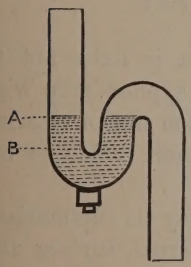


FIG. 19.—Strap with screw. A, B, Water seal.

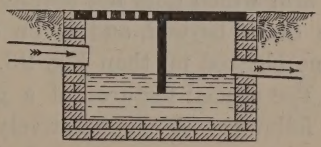


FIG. 20.

useful of them are constructed on the syphon principle. Syphon traps may be described as curved tubes, in which it is necessary that the bend should be sufficient to permit of some portion of the roof of the pipe to be below the water level. What is called the *seal* of the trap is the difference between the surface of the water and the depression at this point (Fig. 19).

Traps constructed on what is called the mid-feather principle have one or more partitions dipping into the water between the entrance and outlet, and the dip of the partition into the water represents the depth of the seal. The objectionable traps of this description are the old-fashioned mason's dip-trap (Fig. 20), the common bell-trap

already referred to (Fig. 21), and the D-trap, which still remains such a dangerous feature in obsolete water-closet and soil-pipe arrangements (Fig. 22). The following syphon traps, though still by no means rare, are also objectionable: —Fig. 23, because the seal is too shallow, is without means

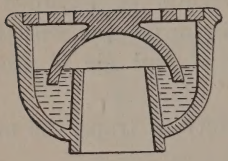


Fig. 21.

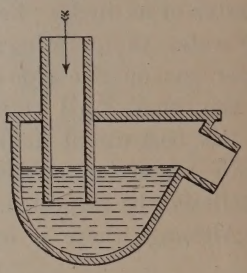


Fig. 22.

of ventilation or access, and having no rest is liable not to be laid true; while Fig. 24 represents a syphon trap with an arm which does not permit of ventilation nor of clearing the drain beyond, and is on the whole more liable to become blocked up than Fig. 23.

The special features of a good trap may be summarised as follows:—A comparatively small internal surface and contents; every portion of the surface washed by every

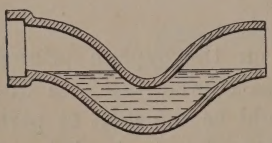


Fig. 23.

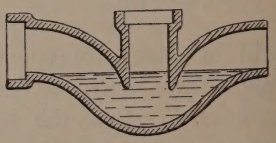


Fig. 24.

flush; no angles, edges, or corners; and a good water seal yet easily cleared.

Water-closet traps should have at least a 2-inch water seal, and the traps on waste-pipes may vary in depth of dip from 2 to 6 inches. These latter should be of the S or half S pattern, or of the kind known as the anti-D trap, but whichever form is used, the lower bend of the trap should be fitted with a movable screw-cap for cleansing purposes

(Fig. 19). No trap to be efficient should have a water seal less than $1\frac{1}{2}$ inch deep. All bath, lavatory, and waste-pipes should be trapped in this way, even when they do discharge on to open gratings, to prevent the entrance of cold or foul air.

Fig. 25 represents a self-cleansing gully trap to receive waste-pipes or rain-water pipes, and Fig. 26 is an illustration of a yard or road gully trap to receive surface water.

Of what are called ventilating intercepting traps, or "sewer-air" interceptors, there is a great variety, but all of them are intended to furnish a complete air disconnection between the pipe, or drain, and the sewer. The air inlet of the trap provides for a constant current of fresh air entering the drain, and passing up the ventilated soil-

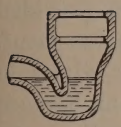


Fig. 25.

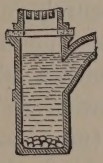


Fig. 26.—Simple Gully Trap.

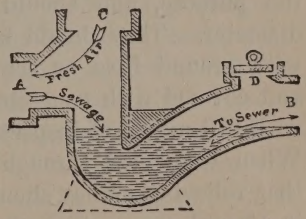


Fig. 27.—A. Socket for house drain.
B. Connection with outfall drain.
C. Socket for fresh air inlet pipe.
D. Cap for clearing purposes.

pipe or other ventilating pipe. Fig. 27 is an illustration of this form of trap, and where a disconnecting man-hole is not provided, the model bye-laws of the Local Government Board enjoin that, as regards new houses, a trap of this description should be used to intercept all house drains from the sewer. As a rule, the trap should contract at its bend to a smaller sectional area than the drain, a 4-inch trap, for example, being sufficient for a 6-inch drain. There should be a fall of at least an inch from the discharging end of the drain to the level of the water in the trap, while the inlet should be vertical or nearly so, and the outlet sloped at an angle of about 45°. The trap should have a foot or pedestal to prevent its slipping from position; and in order to secure more effectual flushing, the drain should have a slightly greater fall towards its junction with

the trap. The air inlet to the syphon is carried by a vertical pipe to the surface, where it is covered with a grating, or if it is in a position to receive dust or pebbles it should be ventilated by means of a small side-chamber, or by a 4-inch pipe carried up some short distance along an adjoining wall. It is always preferable, however, to construct a ventilated chamber in connection with any trap of this description.

(4) *House drains.*—Unless absolutely necessary, no drain which receives sewage should traverse the basement of a house; and when it is necessary, as when houses are joined together in streets or squares, every such drain should be made absolutely air and water tight. Pipes of glazed earthenware 2 feet in length are generally used for the purpose, and should not be less than 4 inches in diameter. They should be laid on a bed of concrete made with ground lime or cement, securely jointed with cement, and covered with concrete. They should also be provided with full means of inspection at either side of the basement. When they pass through foundation walls, it is advisable that relieving arches should be turned over them, because it often happens that they become broken by settlements. The pipes are laid with the sockets pointing to the soil-pipe or head of the drain, and unless special joints are used, such as Stanford's, or what is called the *tongue* joint, great care must be taken that no cement projects into the drain.

House drains which do not pass under the basement need not be laid on concrete, provided the subsoil is sound, and an even firm incline in the bottom of the trench can be obtained; but whether laid on a bed of concrete or on sound earth, it is always preferable to lay the pipes on a series of uniform bricks—a brick behind the collar of each pipe. This enables the bricklayer to thoroughly cement and wipe the joint all round, and when the water test is subsequently applied, any leakage from the joints can be much more readily detected and remedied. The drain when thus laid will appear as a straight barrel from man-hole to man-hole resting on a series of bricks, and when tested it can be filled in with concrete or sound earth, but care must

be taken not to fracture any of the pipes. If the pipes are laid in the bottom of the trench without the intervention of bricks, the body of each pipe should be made to rest on the earth by scooping out a sufficient space for each collar.

Cast-iron pipes of the weight and description constantly made for water mains are now being largely used for house drainage, and though the pipes themselves are more expensive than glazed earthenware pipes, there is much less jointing required. All the safeguards as regards a bed of concrete may be dispensed with, and they may be laid at much shallower depths. Indeed, in America, instead of being carried under the basement, they are often slung on to the beams supporting the ground floor, so that they are always exposed to view. The pipes are cast in 9 feet, 6 feet, and 3 feet lengths, and are jointed together with tarred yarn and molten lead. They should be coated outside and inside with Dr. Angus Smith's composition to prevent corrosion. Cast-iron bends and connections of various shapes and sizes, as may be required, and cast-iron man-holes with cast-iron ventilating intercepting traps, can all be procured for the complete requirements of house drainage, and the pipes can be obtained of 4, 5, and 6 inches diameter. Although the initial expense may be somewhat greater, there can be no doubt that this system affords a far greater guarantee of sanitary safety than the ordinary system of drainage by glazed earthenware pipes. Junctions to soil-pipes can be made more secure, and there is no possibility of leakage in any other part of the track.

If drainage is required to dry the subsoil, a drain with open joints surrounded by gravel should be laid across the basement or round the house, but such drain should never be connected with the house drain unless it is safely disconnected by a ventilating intercepting trap or man-hole. Cellar drains should also be disconnected in the same way, and preferably into an open area.

For average-sized houses the diameter of the house drains should not exceed 4 inches, and pipes of 6 inches diameter are found to be quite capacious enough for large houses or

mansions; but for very large establishments or groups of buildings, an outfall drain of 9 inches diameter may be required. As regards gradient, that of a 4-inch drain should not be less than 1 in 40; of a 6-inch, 1 in 60; and of a 9-inch, 1 in 90,—yielding in each case a flow of between 3 and 4 feet per second.

Drains should always be laid in straight lines, and where

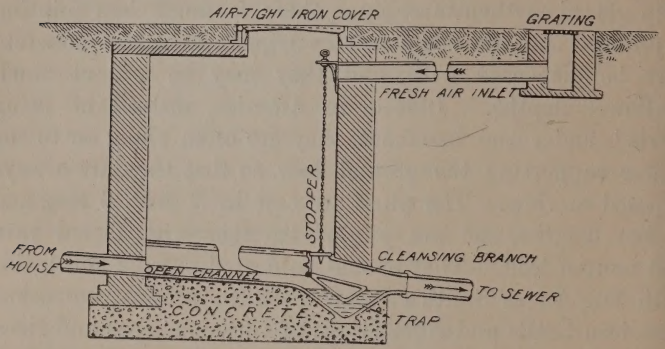


FIG. 28.

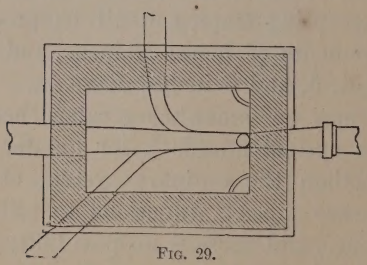


FIG. 29.

a bend is necessary it should be effected by a pipe of proper curve. In connecting branch drains with main drains splayed junction pipes are used, and in connecting a smaller with a larger drain directly, taper-shaped or "reducing" pipes are employed.

When drains pass across areas, yards, or open courts near the surface, access openings are very useful for purposes of inspection. They should be provided with air-tight covers, but should never be fixed inside houses, lest the covers should be negligently left open.

Instead of the simple ventilating intercepting trap (Fig. 27), which may be deemed sufficient to disconnect the drains of small houses, it is necessary that for larger houses an intercepting chamber (Figs. 28 and 29) should be provided at the point of junction of the several drains with the outfall drain. This chamber should be built preferably of white glazed bricks set in cement, or with bricks lined with cement, and on a concrete foundation. The main house drain is continued through the floor of the chamber by means of a glazed channel or white porcelain pipe, and from this the floor of the chamber, which should also be cemented, slopes upwards towards the sides of the chamber. Any other drains which converge at this point are connected with the main channel pipe by other channel pipes (Fig. 29), which should be suitably curved to permit of an easy flow. If the drain from the house is a 6-inch drain, the main channel discharges into a 4-inch syphon trap, provided with a cleansing branch, or "raking arm," as it is called, to permit of the removal of any obstruction on the sewer side of the trap, but which is closed by an air-tight cap or plug when it is not used. If the chamber is situated in a position free from dirt and away from traffic, it may be ventilated by a perforated iron door or grating, but otherwise the chamber should be closed by an air-tight cover, and ventilated either by a 4-inch pipe or through a small adjoining chamber or dirt-box covered with a grating; but in any case the ventilating opening should be in the corner of the chamber opposite the entrance of the house drain.

Fig. 28 shows a second inlet to the raking arm which is sealed by a plug which can be raised by means of a chain or rod. This arrangement commends itself, because in the event of the trap becoming obstructed, the sewage, which would back up into the man-hole, could be liberated by pulling the chain, otherwise, without this contrivance, it would be necessary to empty the man-hole either by a pump or by means of buckets. To render the trap as self-cleansing as possible, it should be egg-shaped in section and curtailed in calibre, as in Crapper's trap.

In carrying out a proper system of drainage for large houses or public institutions, inspection man-holes with close covers should be provided at all points where there are important junctions, or where the main drain changes its course. It may here be noted, too, that in laying down a new system of drainage for old houses, all old drains under or near the houses should be taken up, and any polluted soil removed. It should also be made a rule never to lay a new drain in an old culvert, as is sometimes done, nor connect a new drain with an old outfall drain, unless such drain is found to be in fairly good condition, and proper disconnection be made by means of a ventilated man-hole and intercepting trap. Where new drains are required, old drains should be taken up.

Before they are covered in, all new drains should be tested by the hydraulic test, to discover whether there is any leakage at the joints. This can be readily done by stopping up the lower end of the drain, and either filling from the soil-pipe or from a bent junction fitted temporarily into the head of the drain. (For further remarks on drain testing, see Chapter XIII.)

If the gradient of the house drains is low, and deposit liable to occur, it is always advisable to place a self-acting syphon flush-tank as near the head of the drain as possible. This may be filled by the waste-pipe from a bath, if that is regularly used; or it may be filled at regular intervals, say once a week, from a water-tap specially fixed for the purpose. These tanks are made of various dimensions, some of them of earthenware, and the larger sizes of galvanised iron, to hold 30 to 100 gallons and with a flush-pipe of 3 or 4 inches. They are not, however, suited to receive the waste water from sculleries or laundries, because they are apt to get out of gear by clogging. A preferable form of flush-tank for such waste-water is Adams' flush-gully (Fig. 30). For large houses, or public institutions, a useful flushing arrangement is to make the scullery sink pipe discharge into a large gully trap covered with a grating, which should be flushed by an automatic flush tank to hold 30 gallons at

least and supplied by water from a tap. The rush of water into the gully trap each time the tank discharges effectually clears out all the fat and grease, which are otherwise liable to accumulate, and flushes the drain.

Whether arrangements are required for flushing or not, the house drains so constructed, ventilated, and intercepted, may be connected either with a public sewer, or in country and suburban districts, where there are no public sewers, they may discharge into a cess-pool. In the former case, where pipe-sewers are laid, they should be connected by proper splayed junctions, or if they discharge into brick sewers they should curve in a downward direction sloping towards the fall of the sewer, and discharge above the sewage level. When the sewer is liable to flooding, it is sometimes deemed necessary to provide a tidal valve between the sewer and drain, but this should always be avoided if possible.

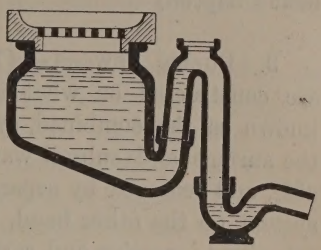


FIG. 30.

Where a *cess-pool* is required to receive the sewage of a country house provided with water-closets, it should be situated at a safe distance from the building, made perfectly water-tight, and be ventilated. It is also of the utmost importance that a syphon trap with ventilated man-hole should be provided in the course of the drain, and preferably at the junction of the branch house drains. The plan of construction should be on the liquid-manure tank principle, the walls being of brick-work set in cement, surrounded by a clay puddle, and lined inside with a coating of cement. Both roof and bottom should be arched, the roof provided with a man-hole, and the bottom built with a fall towards one end, where a chain pump could be fixed. The depth should not exceed 6 or 7 feet, otherwise the increased hydrostatic pressure would necessitate expensive walling. To retain the solids the outfall drain from the cess-pool should be protected by wire meshes or screens. All cess-pools

should be regularly cleaned out, and according to the model bye-laws of the Local Government Board, they should be at least 50 feet from any dwelling and 60 feet from any well. If the cess-pool is situated in a field or orchard some distance from the house, the liquid contents can frequently be got rid of by constructing an overflow pipe leading into sub-irrigation drains, either with or without a flush-tank. (See next Chapter.)

3. Public Sewers.—(1) *Construction.*—Public sewers are constructed on what is called the separate, or that known as the combined, system. In the separate system the surface and subsoil water is excluded as far as practicable, and removed by separate channels. In the combined system, on the other hand, the sewers are constructed of a capacity to receive and carry off the rainfall as well as the sewage and waste water. In London the capacity of the sewers which convey the sewage to the outfall is calculated on the assumption that the sewage averages $31\frac{1}{4}$ gallons per head of the population in the twenty-four hours, and that the greatest average rainfall is $\frac{1}{4}$ inch during the same period. What are called storm overflows, which discharge at various points into the river, are also required to relieve the sewers during times of excessive rainfall.

For average-sized towns there is no doubt that the separate system possesses several important advantages over the combined system; and indeed, in many of them, such as Dover, Ely, Gloucester, etc., the old drain-sewers have been made available to carry off the subsoil and storm-water, while pipe-sewers are found to be sufficient for the most part to convey the sewage proper. The advantages of the separate system, especially when the sewage has to be pumped at the outfall for irrigation purposes, are obvious. The volume of sewage is very much smaller; there is much less fluctuation in the daily and seasonal flow, and therefore greater uniformity in the composition of the sewage; the sewers are kept cleaner, and there is much less liability to the formation of deposit. On the other hand, the separate

system does not ensure the important hygienic condition of drying the subsoil, unless old drains can be utilised for that purpose or separate drains are laid down, or unless subsoil pipes are conjoined with sewer-pipes, as in the system devised by Messrs. Brook and Son of Huddersfield. This consists of flat-bottomed ⊓-shaped-under pipes for the subsoil water, and of circular over-pipes, supported on cradles connected with the under-pipes, for the conveyance of the sewage.

Pipe-sewers are made of various sizes, from 9 inches up to 30 inches in diameter, and the same rules apply as regards laying and junctions which have already been described in connection with house drains. Sewers of larger dimensions are generally made of glazed bricks laid in cement, and the bricks are moulded to suit the curve of the sewer, which should be an egg-shaped oval, with the small end, or invert, downwards. This form of sewer possesses the great advantage that there is greater depth of sewage, less friction, and less liability to deposit than any other form of sewer; although for outfall sewers, when the volume of sewage is large, most engineers prefer the circular form, on account of its greater cheapness and strength.

The inverts of egg-shaped sewers are now generally constructed of glazed stoneware blocks, which are sometimes made hollow to drain off the subsoil water during the construction of the sewer; but in order to prevent fracture from the weight of the brickwork built over them, they are filled in with concrete. All sewers, whether they are pipe-sewers or constructed of brick, should be laid on a bed of concrete, and have their lower segments imbedded in concrete. Small sewers under 3 feet in diameter may be constructed of $4\frac{1}{2}$ brickwork, but for larger sewers 9-inch brickwork is required, and for greater strength two courses of bricks may be necessary.

No sewers or drains should join main sewers at right angles or opposite the entrance of others. They should always join in the direction of the flow of the sewage.

They should also be laid in straight lines from point to point, and when curves are necessary, the radius of the curve should not be less than ten times the sectional area of the sewer. At all important junctions and changes in direction, man-holes or side entrances should be provided for inspection. No catch-pits should be constructed in the bottom of sewers, because the foul excretal matters retained with *detritus* increase the putridity of the sewage and the evolution of highly offensive effluvia. All mud and road *detritus* should be intercepted by gully traps (Fig. 26), into which the gutters and channels on both sides of the roadway discharge, and which should be cleaned out at regular intervals.

The fall or gradient of public sewers should be sufficient to ensure a velocity of not less than 1 foot, and not more than $4\frac{1}{2}$ feet per second,—the minimum fall ranging between 1 in 250 to 1 in 750; though in some flat, low-lying towns, such as Southport, the gradient is sometimes as low as 1 in 5000, but then special arrangements must be made for flushing.

Where the gradients are steep, what are called tumbling bays (Fig. 31) become necessary to prevent the wear and tear of the sewers by the scouring action of the rush of sewage down a steep incline. These tumbling bays are provided with a man-hole and ventilating chamber, while the upper section of the sewer is intercepted at its outfall by a flap-valve which prevents the entrance of sewer gas. In engineering language this is called "ramping" a sewer.

In large towns, with hilly, undulating surfaces, intercepting sewers are constructed along the valley lines to receive the tributary sewers from the more elevated parts, and so divide the town into manageable drainage areas. These intercepting sewers are also especially advantageous at many seaside places, in order that the sewage may be discharged at such a distance from the town as to prevent nuisance on the foreshore.

What is called *Shone's Hydro-Pneumatic System* enables engineers to overcome many of the difficulties with which

they have to contend when a sufficient fall cannot be obtained, or when deep cuttings have to be faced. By means of *sewage ejectors*, which are worked by compressed air, the sewage is forced along iron pipes from one or more collecting tanks, either to the outfall or to any desirable level. The system has been for some time in successful operation at Eastbourne, Henley, Wrexham, Warrington,

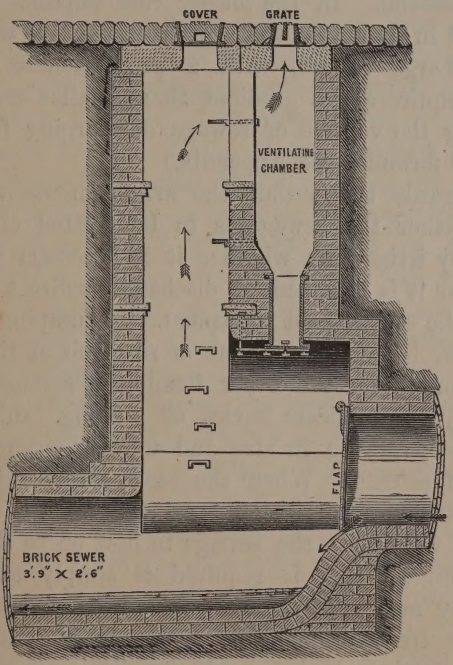


FIG. 31.—Man-hole, Tumbling Bay, and Double Ventilating Arrangement. (After RAWLINSON.)

and other towns, and has also been made available for the efficient drainage of the Houses of Parliament and other large buildings.

When a sewer has to be carried across a river, an inverted syphon constructed of iron pipes becomes necessary, and inspection man-holes are required at either end. Unless the current is of sufficient velocity to carry all solid matters with it, special arrangements must be made to keep the

syphon clear, either by straining the sewage or by periodic flushing, and in order to ventilate the syphon efficiently, a ventilating pipe should be connected with the descending arm. Syphons are also used to convey sewage across valleys when the sewer is too low to permit of bridging.

As has already been pointed out, the *velocity of flow* in sewers should never be less than 1 foot nor more than $4\frac{1}{2}$ feet per second. In the former case deposits are apt to occur, and in the latter, the friction is liable to wear out the invert. Large sewers, with a proportionate volume of sewage, require a less gradient than smaller sewers. (For estimating the volume of sewage discharging from sewers and other formulæ, see Appendix.)

As regards the outfall, the arrangements will depend upon whether the sewage is to be treated chemically or purified by irrigation; whether it is necessary to pump it; or whether it is intended to discharge it direct into a tidal river or the sea without treatment. If pumping is required there must be a storage tank or reservoir at the pumping station; or if, on the other hand, the sewage is treated chemically, a duplicate series of settling tanks must be constructed, varying in size and number according to the volume of sewage. When the sewage of an inland town can be purified by irrigation, and the town is of sufficient elevation to permit the sewage to flow on to the farm by gravitation, all that is required is simply to strain the sewage by means of strong iron screens; and unless the sewage is treated chemically before it is distributed over the land, settling tanks should be dispensed with, though if treated biologically, septic, or bacteria, tanks are required. The mouth of the outfall should, however, be protected or intercepted to prevent winds when they blow in that direction from sweeping back any sewer gas towards the town. When towns discharge their sewage into tidal rivers, the Reports of the Royal Commission on the discharge of the London sewage prove very clearly that the sewage may concentrate near the outfall, and constitute what they have termed a "sewage zone," oscillating back-

wards and forwards with the tides; and when spring tides give place to neap tides, the sewage may be carried up higher and higher above the outfall, and become a source of great nuisance to the inhabitants living on the banks of the river.

As regards seaboard towns, the sewage may under certain circumstances be discharged directly into the sea, but the outfall must be at a point where there is no risk of the sewage being drifted by currents towards the foreshore. The sewer should also be carried far enough out so as to open in all states of the tide below the surface of the water, and the mouth should be protected by a tidal valve to prevent the inrush of sea water as the tide rises. If the town is low-lying, it becomes necessary to construct either what is called an oval tank sewer, or, preferably, one or more storage reservoirs from which the sewage may be pumped or discharged at the fall of the tide. It is in respect to towns so situated that Shone's system, or the septic tank system, becomes especially applicable.

(2) *Ventilation of Sewers.*—In order to prevent concentration or stagnation of the gases which are largely given off by sewage, it becomes a matter of the utmost importance to provide a sufficient number of openings communicating with the sewers, to ensure free ventilation. As already pointed out, main sewers, with steep gradients, should have a man-hole, a tumbling bay, and ventilating arrangements at intervals according to the steepness of gradient (Fig. 31). For ordinary sewer ventilation, however, the man-hole cover without a side-chamber is generally used for ventilating purposes, or efficient ventilation can be secured by making a sufficient number of direct openings into the crown of the sewer, but in all these cases it is necessary to fix a dirt-box under the ventilating grating to intercept any solid matters which would otherwise fall into the sewer. At one time it used to be the practice to place one or more trays containing charcoal in the man-hole to deodorise the sewer air as it escapes, but this plan has been abandoned because it was found that the charcoal greatly impeded free ventilation,

and was but a feeble deodorant. Various other devices have been tried from time to time to deodorise the offensive effluvia issuing from ventilators, such as sulphurous acid gas obtained either from a concentrated solution of the gas or from potassic or sodic permanganate and sulphuric acid, but all such expedients are only palliatives and require constant attention. Another plan, which has been tried with varying success at Ealing and some other towns, is the use of *sewer-gas destructors* which answer the purpose of ordinary lamp-posts. In these a large gas-burner is placed within the base of the shaft which communicates with the sewer, and the other arrangements are such that the organic matter contained in the sewer air is supposed to be consumed as it passes through the flame and up the shaft, but if there is any escape of coal-gas into the sewers, there is always some risk of explosion, and on this account, and their doubtful efficiency in other respects, they are not to be commended.

In cases where the sewer runs parallel with and close to the pavement, it is advisable to carry the ventilating shaft in a sloping direction to an open grating situated in the centre of the street, or to erect a ventilating pipe against the wall of an adjoining building. In narrow confined streets these ventilating shafts become especially necessary, because direct ventilation into the crown of the sewers under such circumstances is often attended with great nuisance. It should also be remembered that the foul effluvia given off by ventilators are frequently engendered by the catch-pits which are constructed below the ventilators to retain road-drift, but which retain excrementitious matter as well. As already pointed out, all such catch-pits should be done away with, and the ventilators be provided with dirt-boxes. Special attention should be given to the ventilation of the dead ends or terminals of sewers, either by ventilating gratings or ventilating shafts, because otherwise they form *cul-de-sacs* for the retention of sewer air.

As regards the number and distribution of ventilating openings, it may be said generally that in addition to the terminals, the junctions of all branch sewers with main

sewers should be ventilated, and according to Rawlinson there should not be less than 18 fixed openings, or 1 at intervals not greater than 100 yards, for each mile of main sewer. Much, however, will depend upon the character of the sewers. If the system of sewerage is new, and the drainage of all houses is intercepted from the sewers, many maintain, and with some show of reason, that only a few openings are required for the escape of displaced air at times of heavy rainfall, and that free ventilation under these conditions is not only unnecessary, but that it greatly conduces to putrefactive changes in the sewage. But in all sewers some deposit forms on their sides, owing to the varying volume of sewage flowing through them, and this deposit, being alternately wet and dry, speedily decomposes, and parts with its putrefactive ferments not only to the sewage itself but to the sewer air. Hence, the great object of ventilation is by means of numerous openings to so dilute the sewer air as to render it innocuous and imperceptible to the senses. Some ventilators will act as inlets for fresh air, and others as outlets, according to the direction of the wind. There can be no doubt that direct ventilation, when properly carried out, is the most efficient, and if sewers are properly constructed in the first instance, and kept well flushed, there should be no nuisance from the ventilators; but where nuisance is found to exist, a ventilating pipe or shaft, carried up an adjoining wall, will be found sufficient to remedy the evil. Indeed, in almost all old towns, the question of sewer ventilation has been greatly modified on account of the large number of soil-pipes which have been ventilated during recent years, and which, unless the house drains are intercepted, act as direct ventilators of the sewers, so that offensive street ventilators can be closed without scruple where ventilated soil-pipes are common.

Main sewers, liable to be affected by the rise of tides or land floods, must be abundantly ventilated in order that the sewer air may not be forced back into the tributary sewers and drains. To provide for efficient ventilation under these circumstances, Drs. Parkes and Sanderson, in

their report on the sanitary condition of Liverpool, recommended the erection of lofty shafts, with a sectional area at least half as great as that of the sewers. They condemned the ventilating shafts in use at the date of the inquiry as being too narrow, and ascertained by experiment that the Archimedean screw ventilators, with which the shafts were supplied, only aided the extractive power by 20 per cent.

No water from manufactories of an elevated temperature should be allowed to enter sewers before being cooled, because it accelerates putrefactive changes in the sewage. Blowing off steam from boilers is also objectionable, and is prohibited by the Public Health (Amendment) Act.

(3) *Flushing of Sewers.*—As offensive discharges of sewer air are largely due to the formation of deposits, careful attention to systematic flushing is highly essential. In addition to special arrangements for the flushing of main sewers, there should also be a flushing chamber or self-acting syphon flush tank at the head of every branch sewer,—such chambers being flushed either from the mains, where there is a public water-supply, or in villages and suburban districts, where there is no such supply, by means of a water-cart. If the flushing is carried out from the mains, care should be taken that there is no intimate connection between these and the sewers. Main sewers are flushed by means of sluices or flushing-gates, which are used at various man-holes as required, and are made to fit the whole or part of the sectional area of the sewer. When these are placed in position they dam back the sewage in the sewer, and on being raised or removed, the rush of sewage effectually flushes a certain length of the sewer below. In large brick sewers, self-acting flood-gates are often used. These gates are hinged below their centre, so that the pressure of the sewage fixes the gate until it rises to a point above the hinge, where, on account of the greater pressure on the upper surface, the gate tilts and assumes a horizontal position, thereby liberating a huge volume of sewage. As the sewage falls to its normal level,

the flushing gate tilts back into position, and so the self-acting flushing process goes on.

With a system of sewage properly constructed, well ventilated, and regularly flushed, the dangers arising from atmospheric pollution by sewer gases is reduced to a minimum. Indeed, the amount of impurities in sewer air under these conditions is so small as to be almost inappreciable to the senses; and it may be laid down as a rule, that whenever foul effluvia are given off, it is an indication that the sewer is insufficiently ventilated, imperfectly flushed, or that it has been badly constructed in the first instance.

Section II.—Conservancy Methods

1. *The Privy or Midden System.*—This system, which formerly was general in most towns, and is still very common in rural and suburban districts, is open to the gravest objections unless special precautions as regards structural details are carried out. Leaky and fœtid cess-pits and large deep midden ash-pits are always a source of danger, even in rural districts. According to the well-known report of the late Mr. Netten Radcliffe to the Local Government Board on Filth-Nuisances, the only kinds of midden-privies which were found to answer sanitary requirements fairly well were the improved midden-steads of Hull and Glasgow, which were constructed so as not to be under the ground level, but even these could not be scavenged without creating nuisance. Other schemes, intended to diminish the offensiveness of large midden-steads, as observed in Manchester, Salford, Nottingham, and elsewhere, were all found to have practically failed. In Manchester, where many of them were drained into the sewers, it was discovered that the sewers were becoming gradually choked up with sediment.

Where privies are still tolerated they should be constructed in accordance with the model bye-laws of the Local Government Board. These enjoin that no privy

should be nearer than 6 feet to any dwelling, nor 40 feet to any well, and it should be so situated as to be readily accessible and to admit of scavenging without the necessity of carrying the contents through any dwelling or place of business. The privy must be well ventilated, and that part of the floor which is not under the seat must be not less than 6 inches above the ground level and with a slope towards the door of half-an-inch to the foot. The floor itself must be paved with hard tiles or other non-absorbent material, and the capacity of the receptacle or space under the seat must not exceed 8 cubic feet. The floor of this receptacle must be in every part 3 inches above the ground level, and both this and the sides must be constructed of impermeable materials,—9-inch brick-work set in cement or asphalted, while the sides may be flagged or cemented. The seat should be hinged to allow the contents to be removed, or other means of access either at the back or side of the privy be provided. In order to keep the contents dry, it is necessary that sifted ashes or dry earth should be used.

When such structural details as these are carried out, there is of course no danger of percolation into the soil, but the difficulty always is to procure a sufficient quantity of sifted ashes or dry earth, or, if procurable, to get people to use them. This is the great difficulty which is always encountered in rural districts, unless the ash-pit, which should also be above the ground level, is connected with the privy. In towns there can be no doubt that some form of the pail system is the only safe system where water-closets are not in general use.

2. *The Pail System.*—In this system the excreta are received into movable receptacles, and according to the model bye-laws of the Local Government Board the construction of the closet should be the same as that which has been described for a properly constructed privy.

In order to carry out this system in the most efficient manner, two pails are required for each closet, one to receive the excreta, and the other the ashes and house refuse. The

excrement pail may be either a wooden pail or tub, as used at Rochdale, Nottingham, and Halifax; or it may be of metal, such as that used in Manchester, Leeds, and Birmingham. In either case it is requisite that it should be round, so that it can be easily cleaned, and as regards capacity and convenience for removal, its cubic contents should not exceed 10 gallons. If of wood it should be tarred or creosoted, and if of metal it should be made of galvanised iron. All pails should be provided with tight-fitting lids, so that they can be carted away without creating nuisance. When one pail is removed, another, which has been thoroughly cleaned after having been emptied at the depôt, should be left in its stead.

The ash-pail should be somewhat larger than the excrement pail, and may be either a rectangular box of handy dimensions, a tub, or a galvanised pail.

In the Goux system, as carried out at Halifax, the tubs are lined with some dry absorbent material, such as chaff, straw, shoddy fluff, hay, dry ferns, or any kind of animal and vegetable matter which is useless for other purposes. The materials are pressed close to the bottom and sides of the tub by means of a mould, which is afterwards withdrawn. A separate bin must be used for the ashes and house refuse; but urine may be emptied into the tub, and is supposed to be absorbed by the lining, the excreta remaining tolerably dry. The tub is removed once or twice a week, according to circumstances.

In Birmingham, Leicester, and other large towns, the pails are used for the excreta alone, while at Nottingham the ashes and other dry household refuse are added. In Manchester the ashes are thrown upon a sifter, which is so arranged that the fine ashes fall into the pails.

In what is called the *dry earth system*, of which Moule's earth closet may be regarded as the type, the receptacle may either be fixed or movable. Moule's closet is made self-acting, and after each stool the requisite quantity of dry earth, about $1\frac{1}{2}$ lb., is discharged into the receptacle. The earth should be carefully dried and sifted; and as regards

soils to be used, rich garden mould is found to be the most absorbent, and sand the least.

Amongst other deodorants or absorbents which have been used for pail closets may be mentioned peat, or seaweed charcoal, which can be recarbonised in a retort, and the carbon used again; a mixture of soot and salt; deodorant powders used with sawdust, etc.; but all these methods are too expensive for general use, and without proper care and supervision they possess no special advantage over the ordinary pail system. Indeed, as regards all populous localities, it may be said that the attempts to economise in town-sewering and scavenging by removing human excreta separately has been a failure, and local costs, as well as local nuisances, have been increased.

(3) *Lieurnur's and other Continental Systems.*—These need only require brief mention. Captain Lieurnur's system may be described as consisting of air-tight iron tanks situated under the streets, which are connected by iron pipes with the closets in the houses. By means of a powerful air-pump, worked by steam, the sewage is sucked along the pipes to these central tanks, and is afterwards converted into *poudrette*. Only a little water is used in the closets. The system has been tried in Amsterdam, Leyden, and elsewhere; but, owing in great measure to its original cost, it has not met with much acceptance. Moreover, it appears to be radically defective in principle, because it is evident that the pipes must become clogged up sooner or later with fæcal matter, and indeed this result is not at all unusual.

The *fosses permanentes* of Paris, Brussels, and other continental towns are huge pits, placed generally under courtyards. They are lined with cement, so as to render them impervious, and are usually ventilated by shafts rising some feet above the roofs of the houses. The contents are removed three or four times during the course of the year by air-tight carts (*tonneaux*), from which the air is exhausted previous to filling, so that the sewage is forced into them through a hose by atmospheric pressure. The closets in

connection with the cess-pools are almost invariably in a filthy state, from the habit of standing on the seat, which appears to be prevalent in private houses as well as in public places.

The system known as *fosses mobiles* is now adopted in many continental towns, and is a great improvement on the system of *fosses permanentes*. The *fosse mobile* is a closed tub placed on a stand with wheels, and connected by a descent-pipe with the different closets or *faïences* of a house. When filled it is replaced by another of the same construction. The *abfuhrtonnen* of the Germans are of a similar description, but in many of the larger towns the bucket or pail under the privy seat is used (Berlin, Leipsic, etc.)

Section III.—Methods best suited for Rural Districts

In villages where the scavenging is undertaken by the Sanitary Authority, it is just as essential that some uniform scheme of excrement-disposal should be adopted as in towns; but in the great majority of country villages provided with sufficient garden space, public scavenging is not necessary, because the solid refuse can generally be safely disposed of in the gardens. The kind of alterations, therefore, which may be required to remove privy nuisance, will depend very much upon existing arrangements. If, for example, the privy abuts against the house, or is not very far from a well, it should either be removed altogether, or be converted into an earth or ash closet, and be provided with a pail to receive the excreta. Inside a house, the only kind of closet which can be used without risk to health must be a properly constructed water-closet or a dry closet of an approved pattern; but in either case the closet must be detached from any living or sleeping room, and be properly ventilated. In country villages, however, the closet accommodation, except in a few of the better-class houses, is situated outside, and is of every conceivable description. In the older villages it is sometimes represented by a rough wooden erection, with a hole dug in the ground to receive the excreta; or

more frequently by a sentry-box looking structure, stuck somewhere near the far end of the garden, and with a stinking leaky cess-pit behind. In more modern villages, however, the privy and ash-pit or midden-stead are found combined; but as a rule the ash-pit is large and deep, leaky and uncovered, so that at all times it is more or less of a nuisance. Then, again, in the few best-class houses provided with water-closets, it is still often found that the sanitary arrangements and appliances are of the most defective description, and that the closet discharges either into a covered cess-pool, from which any gases generated can escape only into the house, or into a village-drain which was not constructed to receive excremental filth.

Such, briefly, are some of the more common varieties of closet-accommodation to be met with in rural districts, and it need hardly be said that the structural defects connected with them are a constant source of nuisance and risk to health. How, then, are these defects to be remedied, legally, in the first place, and with a due regard at all times to efficiency and cost? The privies or closets are generally so low in the roof that to raise the floor above the ground level, it would be necessary in most cases to raise the roof, which would practically mean entire reconstruction; and unless the closet itself is in a dilapidated condition, this may not be necessary. All that the law requires is that any nuisance must be abated, and this can be effected in various ways, but whatever be the alterations, it is necessary that all privy vaults, cess-pits, or deep ash-pits should be done away with, and that nothing should be below the ground level. The only kind of closet adjoining the house or near a well which should be permitted is a pail-closet, properly paved with concrete or asphalt, or blue brick laid in cement. The seat should be hinged in order that dry earth or sifted ashes may be thrown into the pail, and the pail itself may be removed by lifting it out from under the hinged seat, or preferably through a hinged or sliding door at the back or side. If a dry privy is preferred, care should be taken that the riser and walls should be made of impervious material,

as well as the paving, and there should be a hinged or sliding door, preferably at the back, through which the contents can be scraped out. For this kind of privy, as well as the pail closet, a small box should be kept in the closet to contain the sifted ashes or dry earth, and a trowel or other convenient form of scoop should be provided. The kind of pail to be used in a pail closet should be a proper closet pail, with rim, to come close up under the seat, and not a common galvanised iron household pail.

In order to convert a common privy or deep midden ash-pit into a dry midden ash-pit, after cleaning out and filling in with sound earth, the bottom of the ash-pit and under the seat as far as the riser should be paved with blue brick laid in cement; the riser should be sloped and consist of a slate slab or bricks laid in cement; the dimensions, as far as possible, should not exceed 27 cubic feet; and it is absolutely necessary that the ash-pit should be at the back of the seat and not at the side. In many cases it is further necessary to enlarge the opening at back to almost the same width as the closet, and raise the lintel and seat so that the flooring shall not be below the ground level. A sloping cover, made either of tarred wood or corrugated iron, should be hooked on to back of closet to keep out wet, and it should be left open at both ends to secure free ventilation.

It will thus be seen that a considerable amount of latitude may be safely conceded in respect to the methods by which nuisances connected with closet accommodation in rural districts can be removed. In villages, however, in which public scavenging is considered necessary, or in low-lying villages in which there is considerable risk of well-pollution, the only suitable kind of closet is the pail closet. It recommends itself, too, on the score of cheapness, and often renders it unnecessary to remove the closet if near a house or well. As regards alterations for an ash-pit midden, it is very essential that the opening at the back of the seat should be wide enough to permit the covering of the excreta at all times with ashes; all corners should be

avoided as much as possible, and in order to facilitate removal of the contents a door reaching to the floor level should be provided either at the side or back. In rural districts, the kind of closet accommodation to be provided for new houses should be on the lines laid down in the model bye-laws of the Local Government Board as already described. Above all, it is highly essential that special attention should be given to the closet-accommodation of country schools. This should always be constructed on the pail or dry earth system, unless in villages where there is a water-supply, and where a proper system of drainage has been carried out. Under these circumstances trough closets will be found to answer best, not only on account of their cleanliness, but because they do away with all the trouble and expense of scavenging.

Section IV.—Public Scavenging

Except it be in small scattered communities, and perhaps purely agricultural villages, it may be laid down as a rule that no semblance of local cleanliness can be maintained unless the scavenging, as well as the sewerage, be undertaken by the Sanitary Authorities; for, in proportion, as dwellings become aggregated, and populations increase, it becomes more and more difficult for individual householders to dispose of their refuse separately. Fortunately, in the great majority of agricultural villages there is sufficient garden space attached to the houses to permit at all events of the safe disposal of the solid refuse on the premises without creating nuisance, or for exceptional cases there need be little difficulty in arranging for its disposal on some closely adjacent land. Arrangements, for example, may generally be made with some neighbouring farmer, or, as Mr. Haviland has suggested, any exceptional difficulties which may arise from want of sufficient garden space might be overcome if Sanitary Authorities were to provide a spare corner of ground, known as "the muck acre," to which householders could remove their solid refuse. But whenever in any village or

town these difficulties are ascertained to be at all common, it then becomes the duty of the Sanitary Authority of the district to undertake the efficient scavenging of premises, and in case of refusal or neglect, they can be compelled to do so by order of the Local Government Board. In any case, however, the Sanitary Authority is virtually responsible for the cleanliness of its district, either by enforcing the provisions of the Public Health Act for the prevention of nuisance arising from filth-accumulation on individual premises in places to which scavenging does not extend, or by systematically preventing the occurrence of nuisance in places where public scavenging has been introduced.

As regards the general details of public scavenging, much will depend upon local circumstances, and upon the method of excretal removal which may be found to prevail in any particular town. Where the old-fashioned midden system is still allowed to be carried on, the house-refuse is mixed with the excreta, and both are carted away together. In the majority of towns, however, the ashes and other solid house-refuse must be collected and removed by a separate system, which necessitates the use of dust-pails or bins, and the daily or frequent visit of the scavenger's cart. For dwellings occupied by single families the dust-box or pail answers very well, it being large enough to contain the dry refuse collected during the twenty-four hours; and as it is emptied into the scavenger's cart at a stated time daily, any accumulation about the premises is prevented. But in crowded parts, where families live in separate tenements, the whole of the ashes and dry refuse is usually, in the first instance, emptied into a common dust-bin, and afterwards carted away when the bin becomes full. In this case it is necessary that the bin should be roofed in, in order to keep the contents dry, and that it should be well ventilated. No slops or excrement should be allowed to be thrown into it, because the former excite fermentation in the vegetable and animal matters contained in the refuse, and the latter renders the contents offensive. It need scarcely be added

that, in a sanitary point of view, dust-bins or ash-pits should be frequently and regularly emptied.

One very important branch of scavenging in urban districts is directed to the cleaning of streets and back courts, many of which are so badly constructed that it is next to impossible to prevent filth-accumulations. Gutters are often so unevenly laid, that after rain or flushing there are small stagnant pools to be seen throughout their whole extent. The surfaces of macadamised streets, again, are being constantly pulverised, and give off clouds of dust containing large quantities of decomposing animal and vegetable matter in dry weather, or are covered with liquid mud when it is wet; while paved streets present numerous interstices, which cannot be efficiently cleaned out even when scrubbing-machines and flushing are both used. There is no doubt, therefore, that the new plan of street construction which has of late years been introduced into many parts of London and other large towns, whether it be wood-pavement or asphalt, and preferably the former, will not only prove to be economical in many ways, but will also be productive of great sanitary advantages. Tar-asphalt, if properly laid, is especially applicable to side paths, back courts, and narrow streets, where the traffic is inconsiderable, because it is cheap, durable, non-absorbent, and washable.

In water-closeted towns, where only the dry ashes and house refuse have to be dealt with, these may be carted away to shoots, but in large towns the difficulties attending this method of disposal have become so enormous that "Destructors" or "Cremators" are now generally used to burn the refuse. Another method of treatment, has for some time been carried out by a private Company at Chelsea, in which the refuse is sorted by machinery. Each cart-load is tipped into a revolving screen, and from this point the great bulk of the material is separated mechanically. The cinders and fine coal are used to raise steam to drive the machinery; the smaller ashes are made into a black fuel; the paper and rags are manufactured into paper on the premises; bones, glass, pieces of iron, etc., are separated and

sold; the vegetable matter and refuse are ground up with the fine dust, and are available for the manufacture of manure; and the whole process is said to be inoffensive. But in large towns such as Warrington, Birmingham, Rochdale, Leeds, etc., where the pail system still prevails, a more complicated method of treatment becomes necessary, and this may be briefly described as follows:—

(1) *Ashes, etc., collected in ash-tubs.*—These are discharged at the ground level of the depôt, and lifted by an elevator and cast into an automatic cinder-screen, which separates the material into two portions, viz. fine ash and coarser substances. The fine ash is discharged at a point sufficiently high that it can be shot into a cart without labour, and afterwards removed and mixed with such portion of the pail-contents as will furnish a manure sufficient to satisfy any local demand. The coarser materials are discharged into the top of a furnace called a "Destructor," which is also self-feeding, and all that is required is to break up and remove the clinkers. The heat generated in the process of combustion passes under and through a multitubular boiler, and generates steam for furnishing the power required for working the whole machinery. The clinkers from the "Destructor" are passed into a mortar-mill, which reduces them to powder, and this is either sold as sand or mixed with lime to form an excellent and tenacious mortar. At Liverpool, the clinker is broken small, mixed with cement, and moulded into slabs by hydraulic pressure, which, at a cost of 1s. 7d. per square yard, make an excellent pavement.

(2) *Street sweepings, including vegetable and animal refuse.*—This refuse, which consists mainly of sweepings from the markets and streets, is discharged on the ground-level, and raised by an elevator to a platform, and thence passed into a furnace called a "Carboniser," which converts all vegetable material into charcoal. The fuel required for heating this furnace consists of a portion of the sifted cinders from the ash-tubs. The charcoal produced is a powerful deodorant, and may be used for mixing with the pail-contents and sold as manure.

(3) *Pail-contents.*—The bulk of these, which have not been mixed with fine ashes or charcoal, are emptied on the ground level into a covered tank, and are conveyed by means of a chain-pump into an elevated air-tight store-tank. After having been mixed with a small portion of sulphuric acid to fix the ammonia, the thicker portion of the material settles to the bottom of the tank. The more liquid contents are drawn off into two "Evaporators," which are tall cast-iron cylinders, each containing near its lower end a drum-shaped heater, precisely resembling a multitubular steam-boiler. These cylinders are partially filled, and the heating-drums are covered with the thin liquid; steam is introduced into the heating-drums, and the liquid becomes partially concentrated. When the contents have lost by evaporation the greater portion of their water, they are drawn off into a machine called a "Firman's Dryer," along with the thick portions of the pail-contents which have settled in the store-tank. This machine consists of a steam-jacketed horizontal cylinder, traversed by a steam-heated axis and by steam-heated revolving arms, and furnished with scrapers to keep the inner surface of the cylinder free from accumulations of dried excreta. The pail-contents are admitted into the "Dryer" at the consistency of thin mud, and after treatment this mud emerges as a dry powder, resembling guano in appearance and quality, which fetches a good price as manure. All the steam generated is condensed, and the effluvia given off during the process is passed through the "Destructor" fire and destroyed.

Condemned butcher-meat and carcases, which constitute a considerable item of refuse in large towns, may either be steeped in disinfectants and afterwards sold to soap manufacturers, or they may be crushed in a mill called a "Devil," and afterwards treated in a Firman's "Dryer," which separates the fat, and reduces bone and other tissues to a fine fertilising powder.

Among the different forms of "Destructors" used for the burning of house refuse may be mentioned Fryer's "Destructor," Pickford's "Gourmand," and Meldrum's "Sim-

plex." In crowded localities, tall chimneys must be erected to carry off the smoke, and, to prevent nuisance from effluvia, some form of cremator, such as Jones's "Fume Cremator" should be adopted as an adjunct to consume the gases given off. This is constructed in the base of the chimney-stalk, and the gases are exposed to a temperature varying from 1000° to 1500° Fahrenheit.

Local authorities are now beginning to see that the burning of house-refuse may be largely utilised to generate steam for public purposes, as for example, the supply of electric lighting at Shoreditch, and the pumping of sewage at Basingstoke, and there is no doubt a very wide field for economic as well as sanitary advance in this direction.

CHAPTER XI

PURIFICATION AND UTILISATION OF SEWAGE

It has already been shown, in the previous chapter, that of all methods of sewage-removal, the water-carriage system is the one which best meets the requirements of large towns. It is the speediest, cleanest, and, in the long run, the most economical method which can be employed on an extensive scale, and its general sanitary advantages are now placed beyond dispute. But no sooner had this difficult hygienic problem been solved by engineering skill than another of even greater difficulty arose. The eagerness of early sanitary reformers to get rid of human refuse at any cost blinded them to the fact that, by pouring sewage into the nearest watercourse, they were merely removing the evil from one place to take effect somewhere else. No consideration was paid to the probable results of the method on the future water-supply of increasing populations, nor to other serious consequences which speedily began to declare themselves. Rivers were in reality converted into sewers, and the communities down stream, while they loudly complained of the annoyance and danger to health, added to the nuisance by following the general example. After a time it was discovered that valuable stocks of fish were destroyed, that water-supplies were contaminated, and that riparian rights were in every sense grossly violated.

Even in respect to tidal rivers it was found that the crude sewage discharged into them, as into the Thames below London, was found to accumulate and constitute a

"sewage zone," due to the oscillation of the tides, so that the sewage was often carried far above the outfall by the flowing tide to create nuisance and continuously add to the deposits of foul mud. Such were some of the more important evils resulting from river-pollution, and eventually legal prohibitions were issued in many places to prevent their continuance. These prohibitions have multiplied, until the sanitary authorities throughout the country are at last compelled to purify the sewage of towns before it is discharged into any watercourse at a distance from the sea, or run the risk of incurring legal penalties; while the Rivers Pollution Act of 1876 absolutely prohibits any new drainage-works which may in future be carried out from discharging into any river or stream without previous purification.

Meanwhile there has been an increasing number of economists who have maintained that sewage was not only wasted, but worse than wasted, when discharged into rivers, and that, on account of its manurial value, its proper destination was the soil. Hence has risen the larger question of the utilisation of sewage, the merits of which will be best understood by considering first the composition of town sewage.

Section I.—Town Sewage

In addition to excretal matters, town sewage contains the effete products of various trades and manufactures, animal and vegetable *débris*, mineral detritus from roads and streets, and the like, all of which are held in suspension or solution by an amount of water varying according to the water-supply in the first instance, and depending, in the second place, on the rainfall and amount of subsoil water entering the sewers at different times of the year. This varying amount of water is one of the chief difficulties to be encountered in the utilisation of sewage, and, apart from other considerations, it has led engineers to recommend the introduction of the separate system, when there is no

difficulty of dealing with the rainfall. The sewage delivered from pipe-sewers on the separate system consisting almost exclusively of excretal matters, slops, and the water-supply, can of course be readily estimated in all cases, and is much more easily dealt with. But with common drain-sewers, which receive in addition the rainfall and subsoil water, not only is the extent of dilution much greater, but it is constantly varying in amount. With pipe-sewers, however, the amount of sewage practically equals the amount of water-supply, and in towns supplied on the constant system, this ought not to exceed 30 gallons per head daily, or about 50 tons per head per annum. In the face of such considerations as these, the sanitary and practical importance of Mr. F. O. Ward's famous alliterative dogma of "the rainfall to the river, and the sewage to the soil," becomes at once apparent.

But, with either system of sewers, the value of the sewage may be said to depend entirely on the excretal matters, and the amount and relative value of these will be gathered from the following data.

The subjoined table represents, as the result of numerous analysis, the average amount and composition of excretal matter discharged by a male adult daily:—

	Fresh Excrements.	Dry Substances.	Mineral Matter.	Carbon.	Nitrogen.	Phosphates.
	Oz.	Oz.	Oz.	Oz.	Oz.	Oz.
Fæces	4·17	1·041	0·116	0·443	0·053	0·068
Urine	46·01	1·735	0·527	0·539	0·478	0·189
Total	50·18	2·776	0·643	0·982	0·531	0·257

In a mixed population, the actual amounts per individual will obviously be considerably below this average, and, as stated in the previous chapter, they may be estimated at $2\frac{1}{2}$ oz. fæcal matter and 40 oz. urine daily,—the fæces containing 23·4 per cent dry solids, and the urine 4·2 per cent. But the above table also shows that the manurial value of the urine voided in the twenty-four hours greatly

exceeds that of the fæces passed in the same time. Indeed, the relative value, as determined by numerous analyses, is approximately as 6 to 1.

The actual value of both urine and fæces in sewage has been estimated at 6s. 8d. per individual per annum, supposing that 10 lbs. of ammonia is a fair estimate of the amount voided in that time. When the sewage averages 24 gallons daily per individual—that is, 40 tons per head per annum—its money value, according to this estimate, would be 2d. per ton, and the value per ton will decrease in proportion to the rate of dilution above this average. It may be added that this estimate corresponds very closely with the money value of average sewage given in the First Report of the Rivers Pollution Commissioners (1868); for it is there stated that "the value of the *dissolved* constituents in 100 tons of average sewage is about 15s., while the *suspended* matters only contain about 2s. worth of them." In other words, 100 tons are worth 17s., or about 2d. per ton. But no matter what may be considered the theoretical value of sewage in its crude state, it has long since become a question of least cost as regards its disposal.

The following table, from the Report of the Rivers Pollution Commissioners, gives the average amount of solids in water-closeted and midden towns (see Appendix):—

	Per 100,000 Parts.	
	In Solution.	In Suspension.
Water-closeted Towns . .	72	44·5
Midden Towns	82·5	39

It is thus seen that in midden towns the amount of solids in solution is greater than in water-closeted towns, no doubt owing to the smaller quantity of water used for household purposes. But apart from methods of sewage removal, it need hardly be said that the volume and composition of town sewage must also vary greatly in respect to other conditions, such as the separation or inclusion of the

rainfall, the amount of subsoil water finding an entrance into the sewers, and the number and character of the manufacturing processes which are carried on. Then, too, the composition as well as the volume of the sewage of any particular town not only varies from day to day if the rainfall is included, but also from hour to hour. Under ordinary dry weather conditions, the sewage of every town is strongest, and the volume greatest in the early part of the day, whereas during the night it may consist almost exclusively of water from imperfect fittings, leaky mains, or subsoil water. It is therefore evident that in order to obtain an accurate knowledge of the composition of the sewage of any town, several samples should be taken at the outfall during the twenty-four hours, while the flow of sewage should be gauged at each time of sampling. The several samples should be afterwards mixed in the proportion of the flow when each sample was taken, and an average sample is thus procured for analysis.

Section II.—Schemes for the Purification and Utilisation of Sewage

These may be classified under the separate headings of chemical processes, filtration and land treatment, combined processes, and so-called biological processes.

1. *Chemical Processes.*—In all of these processes the main object in view is the purification of sewage by the introduction of chemical agents. The dissolved matters are precipitated to a greater or less extent, and can therefore be separated along with the suspended matters, while the effluent water is supposed to be in a sufficiently pure state to allow of its being discharged into a stream or river without producing any serious degree of pollution. It is needless to say that many of these processes have proved to be signal failures, chemically as well as financially. Fictitious values were given to the resulting manure, and some of the schemes which otherwise might have been attended with a certain amount of success were simply

ruined by being made stock-exchange speculations. Indeed, it cannot be too widely known that, no matter what process may be adopted, Sanitary Authorities must be prepared to pay a subsidy for the chemical treatment of their sewage, because it has long since been clearly established that the manure, or whatever other products may be obtained, will in no case pay, or nearly pay, for the cost of purification. For it is found that whatever process is adopted, the ammonia is left practically untouched, and, along with a large percentage of the dissolved organic matter, it escapes with the effluent, so that the sludge becomes comparatively valueless as a manure, and secondary decomposition always sets in if the sewage is discharged into a stream without filtration.

To ensure the best results from precipitation, it is essential that the sewage should be delivered fresh, after being screened, and that it should be well mixed with the chemicals used before it discharges into the tanks.

These tanks, as usually constructed, are large and shallow, 4 to 6 feet deep, and should be arranged in duplicate series, varying in size and form according to the volume of sewage to be treated. Each tank is generally worked on the continuous flow system—the sewage entering in a shallow stream over a weir extending the whole width of the tank, and the effluent discharging into a channel over a similar weir at the other end. The sewage in its slow passage through the tank is thus kept sufficiently quiescent to permit of precipitation, and at stated times, say twice a week, the tank is emptied by means of a floating valve, and the sludge at the bottom gravitates and is swept into a channel sloping towards the sludge-well, into which it is discharged through another valve. If there is sufficient fall, both the sludge and the effluent may be removed without pumping. When one tank, or set of tanks, is being emptied, the duplicates are in operation. This emptying and cleansing of the tanks must be carried on at regular intervals, otherwise the sludge soon becomes putrid, and on rising to the surface gives off offensive gases. The sludge, which contains 90 to 95 per cent of water, may be con-

veyed along raised carriers on to land, as at Birmingham, and subsequently dug into the soil; or it may be treated in hydraulic filter-presses, which strain out the greater portion of the water and convert the sludge into solid cakes. The sludge of the London sewage is pumped into barges which carry it out to sea.

What is known as the *Dortmund Tank* differs from the usual form of precipitating tank in being of much greater depth, and has been recommended as being less costly and presenting greater facilities for the removal of the sludge. The *Ives Tank* is of this description, and about 30 feet deep. The sewage, after admixture with chemicals, enters the tank through a pipe with perforated radiating arms, at a depth of about 10 feet from the bottom, which is cone-shaped. The pipe for the removal of the sludge reaches to the bottom, and the sludge must either be raised by a pump, or it may be removed by syphonic action, provided the sludge-pipe can be arranged to discharge on a lower level than the effluent out-go. These and similar deep tanks were devised on the assumption that the effluent would be sufficiently purified to be discharged into a stream without further treatment, but this, it need hardly be said, has turned out to be altogether illusory; the effluent is clarified but not purified.

Amongst the numerous precipitating agents which have been tried from time to time, it may be said that lime, sulphate of alumina, and sulphate of iron, used either singly or in combination, have yielded the best results. If either lime water or milk of lime is added to sewage, the lime combines with the free carbonic acid, or it decomposes carbonates of the alkalis contained in the sewage to form an insoluble carbonate of lime, which slowly sinks to the bottom, carrying with it a considerable portion of organic matter, so that a more or less clean effluent is the result. Except when the sewage is acid, the proper amount of lime to be added, according to Dr. Stevenson, should not exceed the hardness of the water-supply. In other words, if a town supply shows 15 degrees of hardness, then 15 grains of

lime, as milk of lime, per gallon of sewage, is the amount generally required. Should lime water or lime in solution be used, 3 to 5 grains would be sufficient. If too much lime is added, the sludge and effluent become alkaline, and putrefactive change sets in more readily. The quantity of lime which is generally used is 1 ton to 1,000,000 gallons of sewage.

When sulphate of alumina is added to sewage the sulphuric acid combines with lime and other bases in the sewage, hydrated alumina oxide is formed, and the resulting flocculent precipitant carries down most of the suspended organic matters with it as it slowly subsides. The effluent, however, is slightly acid, and better results are obtained by a mixture of lime and sulphate of alumina, in the proportion of about 5 grains of lime and 5 grains of sulphate of alumina per gallon of sewage, but as the latter costs about £3 : 10s. per ton, and the former only about £1, the expense is much greater than when lime in solution is alone used.

If a salt of iron is added, such as protosulphate of iron, the sulphuric acid combines with the lime salts, protoxide of iron is formed, and the precipitant carries down with it large quantities of organic matter, some of which it oxidises. When used with lime, it should be added in the proportion of from 2 to 5 grains per gallon of sewage. If used alone, the effluent is somewhat acid, but its use is attended with this disadvantage—that when the effluent is discharged into a stream without further treatment, the banks become blackened by the sulphide of iron which is subsequently formed, and are rendered very unsightly, even when they do not become offensively foul.

In order to determine the comparative merits of these three precipitants, Mr. Dibdin, late analyst to the London County Council, has carried out a very important series of experiments on raw London sewage which are of the greatest interest. Briefly, his exhaustive examination demonstrated the striking superiority of iron over alumina as a precipitant, and that when used in conjunction with lime in the proportion of 3·7 grains of lime in solution to 2·5 grains of

iron sulphate, as much work was effected at a cost of £31,000 per annum, on the basis of treating the whole of the London sewage, as could be effected at a cost of £82,000 per annum by using 5 grains of lime and 5 grains of sulphate of alumina. His results also show that when lime and alumina, with the addition of one-twentieth of their weight of iron sulphate, were used at an estimated annual cost of £178,000 for treating the whole of the London sewage, not so much work could be accomplished as by an expenditure of £54,000, when an amount of 15 grs. of lime in solution per gallon alone was used. According to his experiments, sulphate of alumina is chiefly valuable in clarifying an effluent, and as it is three times more costly than lime, its merits as a purifying agent have no doubt been greatly overestimated. With sewage obtained from other sources, he further ascertained that as much as 52 per cent of the oxidisable dissolved solids could be removed by the addition of only 5 grains of lime in solution, and that if iron sulphate is added to the limed sewage, a total reduction of 69 per cent can be effected, but this high percentage can only be obtained with the sewage of towns drained on the separate system (see Dibdin's *Purification of Sewage and Water*, 1897).

Several of the following processes have been tried and failed, while others are still in use, but it may be said of most of them that they are now only of historic interest as illustrating the costly attempts which have been made to solve the sewage problem :—

(1) *Lime Process.*—This process, as first tried at Blackburn, Leicester, Tottenham, and other places, failed because too much lime was used, and though the sewage was clarified to a certain extent, a considerable quantity of offensive matters held in suspension was dissolved, secondary decomposition set in, in the effluent or stream into which it was discharged, and serious nuisance was created. Lime is only useful as a preliminary to filtration or land treatment. In *Scott's process*, which was tried at Ealing and West Ham, clay was added to the lime and thoroughly mixed with the

sewage in the outfall sewer. The sludge was dried and burnt, and subsequently converted into cement or bricks, but the effluent was far from satisfactory.

(2) *Alumina Processes.—Bird's process*, which was tried at Cheltenham but abandoned, consisted in the addition of crude sulphate of alumina, and subsequent filtration through coke. The sulphate of alumina was obtained by treating pulverised clay with strong sulphuric acid. In this, and *Stotherd's Process*, which somewhat resembled it, the effluent was not found to be sufficiently purified for admission into any river.

In *Anderson's process*, which has been carried on for many years at Coventry, the sewage is mixed with a saturated solution of sulphate of alumina heated to the boiling point, and afterwards with milk of lime. The sludge is treated in Johnson's filter-presses, and the effluent is subsequently run on to land, but the area is too limited to secure efficient filtration, and there is therefore serious pollution of the adjoining stream. This process is about to be abandoned for irrigation and land filtration.

(3) In what is called the *A. B. C. process*, which has been carried on for several years at Aylesbury, a mixture of alum, clay, magnesic sulphate, charcoal, and blood is added to the sewage. The blood may be regarded as a negligible quantity, but the clay carries down with it the precipitating matters, and the resulting effluent is said to be fairly clarified.

(4) In *Hanson's process*, which is carried on at Leyton and Tottenham with fair success, black-ash waste is used in conjunction with lime. The waste is prepared from the refuse of alkali works which has long been exposed to the air, and contains sulphites and hyposulphites of lime.

(5) The *Electrolysis process*, which was tried at Crossness, and the *Hermite process*, which was tried at Worthing, need only be mentioned in passing. Both of them are electrical processes—the former electrolysing the sewage, and the latter the sea-water to be mixed with the sewage; and though a certain amount of precipitation was effected

by each, the results were disappointing, and the cost prohibitive.

(6) Another process, which some few years ago aroused a good deal of attention, was called the *Amines process.* This consisted in adding lime and a little herring brine to the sewage—the last surely a strange, and somewhat scarce, specific.

But there is no need to prolong the list either of the more or less successful processes or the dismal failures. Chemical precipitation, no matter what the process, only effects one thing, namely, the separation of the matters in suspension, and though it is true that a certain proportion of the dissolved impurities may also be carried down, in no instance is this fully assured. The effluent may be clarified, but it cannot be purified unless the process is supplemented by filtration or land treatment.

2. *Filtration and Land Treatment.*

(1) *Simple Filtration.*—In this process, whether the filtration be downward or upward, the sewage is merely strained or screened through gravel and rough sand, so that though almost all the suspended matters are removed, the effluent remains unpurified, unless the size of the filters is of sufficient area and they are used on the intermittent system. As will be presently shown, filtration to produce a satisfactory effluent, must be carried out on biological lines.

(2) *Intermittent Downward Filtration.*—This process of land treatment is the one which yields the best results. The soil should be of a porous and loamy character, and should be drained to an average depth of 6 feet, with varying distances of from 10 to 20 feet between the drains. Sandy soils are not so suitable, and clay and retentive soils should be broken up and mixed with ashes. The surface of the land must be levelled, and it is generally the practice to lay out the filter beds in ridges and furrows,—the sewage flowing along the furrows, whilst vegetables or roots are grown on the ridges.

The purification of the sewage is partly effected by

simple filtration, but in a far greater degree it is due to the nitrifying organisms in the soil, which convert the ammonia and organic matters into nitrous and nitric acids, and in order that these may readily combine with bases, it is necessary that the soil or sewage should be rich in salts of lime, otherwise the nitrifying process is greatly impeded. Moreover, as nitrification depends in great measure upon the efficient aeration of the soil, it is necessary that the sewage should be applied to different portions of the filtering area alternately. Thus, if the area is divided into four equal parts, each section should receive the whole of the sewage for six hours in succession, and leave an interval of eighteen hours for rest and aeration.

The requisite extent of filtering area for intermittent downward filtration varies according to the nature of the soil, but if the sewage is first screened, one acre of loamy porous land would be sufficient to purify the sewage of 3000 to 5000 inhabitants. When crude sewage is applied to small areas of land, the surface and pores of the soil are apt to become clogged with slimy matters, and the surface should therefore be frequently broken up. In stiff clayey soils, again, large cracks are apt to form during warm weather, down which the sewage may run directly into the subsoil drains, but whatever the nature of the subsoil, if the filtering area is neglected, moles and rats speedily make direct openings for the passage of the unfiltered sewage. Under favourable circumstances, however, and with proper attention, the effluent water issuing from the deep drains will be found to be almost entirely free from organic matters. The amount of chlorine in the sewage will not be found to be materially reduced, but the whole of the nitrogen will only exist in the harmless form of nitrates and nitrites. Land filters planted with osiers are sometimes employed for the purification of village sewage, and these osier beds are often a useful adjunct to filtration areas for the occasional treatment of storm water.

The process of intermittent downward filtration, combined with irrigation, is successfully carried on at North-

ampton, Abingdon, Malvern, Dewsbury, and Forfar in Scotland. There is no precipitation of the sewage, but the solids and sludge are retained in tanks and the sewage more or less screened (see *Purification of Sewage*, by E. Bailey-Denton, 1897).

(3) *Irrigation.*—It has hitherto been conceded that when a sufficient area of land can be obtained at a fair rate, this is the only process which fully meets all the requirements attaching to the disposal of sewage; in other words, it is the only one which, while it purifies the sewage efficiently, realises the highest returns, and may be carried on without creating any nuisance or detriment to the health of the neighbouring inhabitants. But in order that the process may be carried out satisfactorily, it is necessary—

(1) That the acreage be sufficient. This will depend in great measure on the looseness or porosity of the soil;—hence to lay down as a rule that one acre should be allowed for every 100 inhabitants, which is the estimate usually given by engineers, is manifestly illogical.

(2) The land to be irrigated must be drained, and stiff clayey soils broken up and mixed with ashes, sand, or lime.

(3) The surface must be irrigated on the intermittent system, to ensure sufficient aeration of the soil.

(4) The ground should be laid out in broad ridges and furrows, the sewage being conveyed along the tops of the ridges in open carriers, and made to flow gently down the slopes by inserting temporary sluices in regular succession and at regular intervals. At Leamington sewage farm, belonging to Lord Warwick, the ridge varies from 50 feet wide and under, according to circumstances. If the surface of the ground slopes gently, ridges may be dispensed with, and the grips or carriers dug at varying distances as required.

(5) There must be a rotation of crops, such as Italian rye-grass, different roots, cabbages, etc., and where land is plentiful, it always pays to let portions of it rest for a time for the growth of cereal crops.

(6) The sewage should be delivered in a fresh state, and freed from the coarser portion of its suspended matters.

This may be effected either by precipitation, filtration, or screening. At Lord Warwick's farm, the borough of Warwick farm, and the Rugby farm, the sewage is simply screened and delivered fresh on to the land.

A large well-drained filter-bed is of great service to a sewage farm, to receive the whole or part of the sewage at times when the farm is unable to cope with it. Such a filter-bed should, however, only be used on the intermittent system, and a good plan is to plant it with osiers.

Such, briefly, are the principal details connected with sewage-farming, and it is the neglect of one or more of them which has brought so much opprobrium on the system. If the irrigated soil becomes water-logged and swampy, the fault lies with the engineering and management, not with the system. Or, again, if the farm becomes a nuisance, it is because the sewage is not properly distributed, or the carriers kept free from deposit. When sewage farms are let, therefore, it is always advisable that supervision should be exercised by the sanitary authority to secure proper distribution of the sewage, and insist on carriers being kept clean.

Few sewage farms can be worked at a profit, although Lord Warwick pays a rent of over £200 a year for the sewage of Leamington, and uses it on his own land.

Where no land can be procured, as in the case of numbers of large inland towns, recourse must be had to precipitation, supplemented by specially constructed filter-beds, or to a well-arranged biological scheme; but even were all trade refuse and sewage excluded from streams, the mere surface-washings of large towns are sufficient of themselves to convert many of them into foul rivers, which no legal enforcement of riparian rights, nor any number of Rivers Pollution Bills, can ever render pure. Indeed, at Birmingham, Leeds, and other inland towns, the effluent is much purer than the filthy streams into which it discharges. Sanitary reformers are too apt to forget that, though streams and rivers may, and often do, prove valuable sources of water-supply, they are nevertheless the natural drainage outfalls of the country: and while many of them may be

preserved from injurious pollution, there are numbers of others doomed to such an amount of pollution that, no matter what preventive means may be adopted, fish cannot live in them, and their turbid waters, however carefully purified, can never be safe to drink. It is evident, therefore, that with regard to river pollution the special circumstances of every large town involved in sewage difficulties must be taken into account, and that no hard-and-fast rule can be enforced by Act of Parliament which shall be applicable to all alike.

The Rivers Pollution Commissioners recommended that no effluent should be allowed to discharge into a stream which exceeded the following standard:—

		100,000 Parts
Suspended Matter	Dry organic	1
	„ mineral	3
Dissolved Matter	Organic carbon	2
	„ nitrogen	0·3
Metals (except calcium, magnesium, potassium, or sodium)		2
Arsenic		0·05
Chlorine (free after addition of sulphuric acid)		1
Sulphur (as sulphides)		1
Acidity (hydrochloric acid)		2
Alkalinity (caustic soda)		1
Oily matter (petroleum or hydrocarbon oil) or any film of oil on the surface.		0·05
Colour. Any distinct colour in depth one inch when examined by daylight in a white vessel.		

It may be here stated that the Thames Conservancy Commissioners do not insist upon so high a standard, and in the light of recent investigations, the standard as to organic carbon and nitrogen should be replaced by a standard representing oxidisable organic matter.

The purification of liquid trade refuse from manufactures lying outside drainage areas often presents very considerable difficulties, and some very interesting experiments have recently been carried out by the State Board of Health of Massachusetts, with respect to the treatment of liquid waste from tanneries, paper mills, and wool-scouring factories which is indicated as a necessary preliminary to successful

filtration or land treatment (see *Massachusetts Board of Health Report*, 1897). The kind of treatment required for the purification of liquid refuse, will, in all instances, depend upon the character of the waste;—if acid, it must be rendered neutral by lime or some other alkali; if highly alkaline, treatment by ferrous or aluminum sulphate is indicated; if fatty matters have to be dealt with, calcium chloride will precipitate; if arsenic is present, as in tannery liquid waste, it can be removed by filtration through coke or iron filings by the formation of an insoluble double salt of iron and arsenic; and so on. By straining, suitable chemical treatment, and subsidence, further purification by filtration or land treatment is rendered possible when required, and a satisfactory effluent in all cases may be ensured. But where manufactures are carried on within drainage areas, it is obvious that so long as there is no injury done to sewers, nor any offensive gases evolved by admixture of the trade effluents with the sewage, it is a wiser policy on the part of local authorities to treat such effluents at the outfall as integrants of the sewage by chemical precipitation if necessary, than to insist on expensive processes at the works themselves, where the difficulties of dealing with the sludge always tempt to rush imperfectly treated waste into the sewers whenever opportunity occurs. At Birmingham, for example, where there are numbers of galvanising iron works producing large volumes of acid waste or "pickle," no crippling restrictions are enforced.

3. *Combined Processes.*

As already stated, many farms are laid out to treat sewage without chemical precipitation, partly by intermittent filtration and partly by irrigation, while in other instances, as at Birmingham, the sewage is first clarified by precipitation, and subsequently utilised on a large farm, which will shortly be greatly extended in area. At Birmingham, the sewage is mixed with lime in the course of the outfall sewer, and the resulting sludge is ultimately dug into the ground.

Among works in which chemical treatment is supplemented by filtration through specially constructed filters, may be mentioned the Richmond Main Sewerage Works which were completed in 1891, and the Dalmarnock Sewerage Works, only recently completed, which deal with the sewage of the East End of Glasgow. Both these works are arranged on somewhat similar lines, but they differ in the chemicals used. In the former, the precipitants are 3 to 4 grains of milk of lime per gallon of sewage, and a mixture of sulphate of albumina, carbon, and iron, 6 to 7 grains per gallon ; while in the latter, the precipitants employed are milk of lime and sulphate of alumina only.

As the Dalmarnock Works are the most recent development of a combined process on a large scale, the following brief description may be of interest. After straining and admixture with lime and alumina, the sewage flows into a series of twenty-four precipitation tanks, each 50 feet by 40 feet by 6 ft. 6 in. average depth. The tanks are worked on the intermittent system, and the sewage is drawn off from them by floating valves. It is then aerated by flowing over a series of shallow steps in corresponding aerating tanks, and finally passed through a series of coke filters by upward filtration, and then through a series of sand and gravel filters by downward filtration, to the effluent channels which discharge into the Clyde. The sludge from the series of precipitating tanks is drained off through valves into underground channels leading to a huge sludge tank. From this tank it is raised by means of compressed air into two sludge mixers in which it is mixed with lime. From these it flows into four cast-iron sludge-rams, from which it is forced by compressed air into seven filter presses and from them falls into railway waggons ready for removal.

The whole of the machinery is driven by two pairs of tandem condensing engines of 120 horse-power, and the total cost, including the purchase of the site of 28 acres, buildings, tanks, filters, etc., amounted to £115,000. The quantity of sewage treated amounts to 10,000,000 gallons

daily, but eighteen additional tanks of larger size are in course of construction, which will permit of the treatment of a total volume of 25,000,000 gallons daily (see *Journal of State Medicine*, May 1897).

Mention should also be made of several towns at which a combined process is carried on by the International Sewage Purification Company, such as Acton, Walsall, Hendon, Huddersfield, and Pendlebury, with, it is said, fairly successful results. The precipitant used is a proprietary article called *ferrozone*, consisting chiefly of salts of alumina and iron, and the effluent is passed through filter-beds made of gravel and *polarite*, a specially prepared form of iron-ore. Up till quite recently, it was believed that this and other preparations of iron used as filtering media possessed special deoxidising properties, but it is highly probable that the degree of purity which is obtained in the effluent, is entirely due to microbial action.

4. *Biological Processes.*

Ever since Pasteur's researches into the processes of fermentation and putrefaction, there has been a growing conviction that the micro-organisms which play such an important part in the disintegration of organic matter, whether animal or vegetable, might be utilised on a scientific basis for the reduction of refuse and sewage into harmless by-products. The success attending the dry-earth system of treating fæcal matters, and of sewage-farming in purifying liquid sewage, had all along been illustrations of the biological or bacteriological process of sewage treatment, although the *rationale* of the process was not fully understood. Indeed, it was assumed, until quite recently, that the oxidation of decaying organic matter over the earth's surface was mainly a chemical process. The researches, however, of Schlœsing, Warrington, Hunter, and others, already referred to, not only proved that the surface layers of the soil teem with micro-organisms in proportion to the amount of organic matter which it contains, but that they feed upon this matter, and break it up into comparatively

simple oxidisable substances. According to Dr. Sims Woodhead (see *Harbden Lectures*, 1897), the *aerobic* organisms, which thrive nearest the surface, utilise some of the organic constituents for their own food, while the other molecules, which are left in a "nascent condition," seize upon the oxygen of the air which is for ever circulating through the interstices of the soil, and form various combinations of carbon, nitrogen, and hydrogen with oxygen, which, in their turn, become suitable food-stuffs for the nutrition of plants.

At varying depths, according to the nature of the subsoil, the oxygen in the inspired air, so to speak, is practically used up, and is largely converted into carbonic acid gas and water. The organic matter, which is washed down or filters through the upper layers, is then seized upon by the *anaerobic* organisms, which require for their nutrition the oxygen contained in these organic compounds, and the resulting decomposition sets free large quantities of gas,—such as marsh gas, ammonia, sulphuretted hydrogen, and other products, some of which combine with the lime, magnesia, and other bases in the soil to form various salts, and others find their way to the surface to become oxidised, and add still further to the store of food-stuffs for plant life.

As a rule, there are no organisms found at a greater depth than 10 or 12 feet, because at that depth all the organic matter washed into the soil has been broken up, and the processes of decomposition and mineralisation, as it is called, is complete. This is the process of natural purification which goes on in the earth itself, in the soil of grave-yards and sewage farms, and is an essential element in the long recognised purifying agency of plant life in dirty ditches and polluted streams.

It is contended, therefore, that in devising schemes for the purification of sewage, nature's process should be imitated as far as possible, and as the sewage to be dealt with is liquid, three essentials are required,—(1) that the solids in suspension should be got rid of, either by pre-

cipitation or by rendering them soluble; (2) that the best available means should be adopted to permit of microbial action; and (3) that oxygen should be abundantly supplied by aeration in order that the dissolved organic matter may be fully broken up or oxidised by microbial action.

(1) *Scott Moncrieff's System.*—As sewage teems with both aerobic and anaerobic micro-organisms it is not necessary that the media for aeration should contain them. The sewage itself supplies the food, and therefore the aerating media or material may in itself be practically sterile. As has been pointed out by Dr. Sims Woodhead, the first systematised attempt to purify sewage on these lines in this country was made by Mr. Scott Moncreiff in 1891-92. Mr. Moncrieff's process was carried on by means of "cultivation tanks," which were large tanks filled with masses of flint. The surfaces of the flints, when the tanks were filled with sewage, speedily became covered with micro-organisms which "peptonised" the solid matters in suspension, and thus rendered it soluble and ready for further treatment. In order to complete the process, Mr. Moncreiff proposed to add a certain volume of oxygenated water, and then to pass the whole on through a "nitrification" channel which consisted of broken flints or stones, over which the sewage flowed, so that a continuous absorption of the oxygen from the air might take place. Where this was not possible, he suggested that the peptonised sewage should be turned into an adjoining stream for aeration and nitrification. The results, according to Dr. Sims Woodhead, were superior to anything that had been previously obtained.

In respect to filtration, the experiments carried on by the State Board of Health of Massachusetts during 1888-90, had shown that with the various kinds of material used, gravel-stones gave the best illustration of the essential character of intermittent filtration of sewage. In the experiments with gravel-stones, and without straining the sewage sufficiently to remove even the coarser suspended particles, the slow movement of the liquid in thin films over the surface

of the stones, with air in contact, caused to be removed for some months 97 per cent of the organic nitrogenous matter; while the results of other experiments as to the effect of filtration by exclusion of air, that is, by continuous, instead of intermittent filtration, showed that "no nitrification takes place, and the effluent gradually becomes worse until it contains as much organic matter as the sewage" (see *Report of State Board of Health*, 1890).

Following upon the Massachusetts experiments, it was suggested by Mr. George Waring jun., U.S.A., that if air is continuously supplied to a filter, the intermittent process may be dispensed with. On this principle, Mr. Sidney Lowcock of Birmingham, has devised a filter-bed which can be continuously aerated at its centre by means of a blower, which forces the compressed air through a pipe communicating with perforated pipes laid between two thick layers of fine broken stone. In order to regulate the flow of the sewage, a 3-inch layer of sand is laid on the top of the filter, but it is evident that such a layer must soon require scraping or renewal, and though the system is ingenious it would in all likelihood be much more costly in the long run than a larger filter-bed arranged for the intermittent process. This always ensures sufficient aeration, because a recharge of air must follow each dose of sewage, and if the filtering material is finer on the surface, there is always a large volume of air in the interstices below.

It is right, however, to state here, that, as far back as 1886-87, both Mr. Dibdin and Dr. Dupré had contended that whatever chemistry could effect in the purification of sewage must be subordinate to biological considerations, or in other words, that sewage could only be effectually deoxidised by microbial action. Following the publication of the Massachusetts report, Mr. Dibdin in 1892-93 instituted a series of experiments with the London sewage, after straining or precipitation, with a view of solving the problem of treating large volumes of sewage on biological lines, and of determining the rate at which sewage might be filtered intermittently through various materials, such as

pea ballast, coke breeze, burnt clay, and a proprietary material. These experiments were so encouraging that Mr. Dibdin felt warranted in recommending the construction of a filter one acre in extent at the outfall works Barking, Creek, which was drained with perforated pipes,—the filtering material consisting of 3 feet of coke breeze covered with 3 inches of gravel.

The experiments were carried on from 1894 to 1896, and uninterruptedly during the last year, on the following system, namely, alternate filling, resting full, and emptying, with twenty-four hours' rest each week. The volume of sewage treated daily, including periods of intermittent rest, was 1,000,000 gallons, and the reduction of oxidisable organic matter was 75 per cent. The filtrates, moreover, were found to be "sweet and clean, and the filter was apparently capable of continuing for an indefinite time" (see Dibdin's *Purification of Sewage and Water*, 1897).

The Massachusetts experiments with raw sewage showed that a filtering area of 16·6 acres would be required to treat 1,000,000 gallons daily, and a filter with air continuously pumped through the interstices on Mr. Sidney Lowcock's system, would require an area of 3·8 acres to deal with the same quantity.

(2) *Mr. Dibdin's System, or Sutton Process.*—As a result of his most recent experiments carried on at Sutton, Surrey, Mr. Dibdin claims that he has demonstrated conclusively that by the adoption of the system of biological treatment, expensive chemical processes can be dispensed with, and sewage farms, if in populous neighbourhoods, converted into parks. He also holds, and with every show of reason, that there is no longer any excuse on the score of outlay for seaside watering-places polluting the foreshore by discharging their crude sewage through long reaches of outfall sewers into the sea, or into tidal rivers. At Sutton, the system which is being gradually modified to replace the previous system of chemical precipitation and land treatment, is as follows:—The old precipitating tanks are filled with burnt ballast, and are used as in Moncrieff's system as "bacteria

tanks." The tanks when first started were inoculated with bacteria by simply passing raw sewage through them until full bacterial action was ensured. The sewage, before it discharges on to the tanks, is first strained or screened, but no chemicals are used, and as Sutton is drained on the separate system, there is very little grit. After resting in the bacteria tank or bed, the sewage then passes on to secondary filter-beds constructed, preferably, of coke breeze, and the effluent is sufficiently purified for discharge into any stream.

The following is a summary of results obtained during a period of seventy-six days' experimentation :—Total number of gallons treated 2,211,000, or at the rate of 773,000 gallons per acre per day, rest included. As the sewage contained 54·5 grains of suspended matter per gallon, the sludge disposed of by bacterial action was equal to 77 tons, containing 90 per cent of moisture, or an average of about 1 ton daily. The reduction of oxidisable organic matter in solution in the tank was equal to 66 per cent, and of the suspended matters, to 95 per cent; while the further treatment by the coke-breeze and other filters effected a total reduction of 86·5 and 99·6 per cent respectively.

The results of a series of analyses taken during the period, exclusive of the chlorine, and nitrogen as nitrates and nitrites, and represented in grains per gallon, were as follows :—

	Oxygen absorbed in 4 hours.	Free Ammonia.	Albuminoid Ammonia.	Suspended Matter.
Crude Sewage . .	4·543	8·774	0·792	60·03
Effluent from Bacteria Tank .	1·674	2·103	0·329	2·78
Filtrate from Coke-Breeze Filter . .	0·644	0·671	0·170	0·725

These results are certainly very striking, and may be fitly supplemented by the following quotation from Mr. Dibdin's work already referred to :—" With the exception of

a few days when the filter was overworked, the sewage odour was completely removed, there being in the effluents only an earthy odour similar to that of freshly-turned garden soil.

"It appears from these results that a bacteria tank or tanks of half an acre will be sufficient for the complete disposal of the sludge by this system without any expense for labour other than that necessary for turning on the valves, and raking over or digging with a fork, the surface of the ballast from time to time as may be required, to break up the surface-coating of fibrous matter."

The sewage of Sutton, it should here be stated, averages 400,000 gallons daily, and represents the sewage of a water-closeted town, drained on the separate system. Hitherto the cost of chemical treatment averaged £1200 annually, equal to a rate of 4d., so that where tanks for precipitating purposes are in use which could be converted into bacteria tanks, and there is a sufficient area of adjoining land available for the supplemental coke-breeze filters, a very considerable saving would be effected by adopting a biological process.

As to the cost of constructing bacteria tanks and filter-beds, Mr. Dibdin states that where the subsoil is clay, the cost of digging out the clay to a depth of 3 feet, burning it on the spot, and constructing a filter with the burnt clay on the dug-out space would be about £1000 per acre. Such an estimate, however, must be subject to considerable modifications according to local circumstances. But where clay is not procurable, coarse screened gravel may be readily available, or coke breeze may be procured at a cheap rate, or shingle as at sea-side places. Then, in respect to towns provided with cremators, the clinkers from the burnt ashes and house refuse would, if broken up, make suitable filtering material. Evidently, therefore, the question of cost must be relative, but judging from the experiments carried out at Barking and Sutton, a set of bacteria tanks and filter-beds of a total area of $2\frac{1}{2}$ acres would be sufficient to purify 1,000,000 gallons of sewage daily, at an average initial outlay, exclusive of land, say of £4000.

The tanks and filter-beds should be arranged in duplicate,—the tanks of a capacity to hold the whole of the twenty-four hours' sewage, and the filter-beds of the same capacity or greater. Mr. Dibdin indicates generally that the process should be conducted as follows. "The sewage, after screening, should be allowed to flow on to one of the coarse beds or tanks during twenty-four hours, and at the expiration of that time should be diverted on to the other, whilst that which has collected in the first should be allowed to discharge slowly on to one of the fine filter-beds. At the end of twenty-four hours the sewage flow should be diverted on coarse bed (tank) No. 1; the water stored in coarse bed No. 2 should be allowed to pass slowly on to fine filter-bed No. 2, and fine bed No. 1 should be gradually emptied. In some cases it might be desirable to have a third pair of beds in order to put one of the others out of action occasionally for a rest."

Judging from the risk of nuisance likely to arise during warm weather, especially if the surface of the beds is not occasionally broken up, it would be eminently desirable to have at least three pairs of beds in all cases, and very probably too it will be found that additional land properly drained and laid out, or some extension of the filtering area, will be required to secure a uniformly good effluent.

(3) *Mr. Cameron's System, or the Septic Tank Process.*—This system, devised by Mr. Cameron, Borough Surveyor of Exeter, may be described as an adaptation of the old-fashioned dumb-well or cess-pool, as a preliminary, arranged on a scientific basis, to intermittent downward filtration through specially constructed filters. Both Dr. Sims Woodhead and Mr. Dibdin have written very appreciatively of the system; and indeed the only difference between the bacteria tank and the septic tank is this,—that the former is an open tank or bed filled with coarse filtering material, while the latter is a covered tank filled with sewage only; but as regards both it is claimed that the suspended matters contained in the sewage which passes through them are rendered soluble by bacterial action, so that all the heavy

outlay attending chemical precipitation may be dispensed with. It has often been a matter for surprise that there was so very little deposit found in the old dumb-well, even if not cleaned out for years, and so in the septic tank, the residue, or "burnt-up ashes," so to speak, resulting from bacterial action, accumulates so slowly that in the experimental tank at Exeter the deposit was only 15 inches deep after being constantly at work for ten months. The residual matter, therefore, would only require removal at long intervals.

The experimental tank is 64 feet long, and at its upper end there is formed a grit chamber by a submerged cross-wall 7 feet from the entrance, and 1 foot below the surface of the liquid in the full tank. The tank is of a capacity of 53,800 gallons, and is large enough to hold the sewage of about 1500 inhabitants in twenty-four hours, the amount treated daily. The sewage is not screened, and only the silt is retained in the grit chamber. The passage of the sewage through the tank is so slow that there is gradual deposition of a very large proportion of the solid organic matter, while small masses are carried to the surface by the gases of decomposition, and form a leathery scum or layer. But both in this layer and the deposit at the bottom, constant disintegration keeps pace with constant addition of undissolved matter, so that, as Dr. Sims Woodhead puts it, "there is a process of peptonisation, digestion, and liquefaction, similar to that which takes place in the stomach and intestines of animals, going on, not only at the surface, but also in a very marked degree at the bottom of the tank." The micro-organisms at work liquefying the surface layer are mainly aerobic, while the disintegration going on at the bottom of the tank, is carried on by anaerobic organisms. The gases evolved consist of carbonic acid gas, ammonia, methane, and sulphuretted hydrogen, but owing to rapid oxidation, no offensive smells can be detected in the neighbourhood of the tank.

The effluent from the tank discharges through a slotted pipe 16 inches below the level of the sewage in the tank so

as to exclude the surface scum, and passes into a trough closed at both ends, over the sides of which it flows in a thin layer into a channel beneath, and is thus aerated. By means of an automatic arrangement of syphons, and overflows into buckets, the effluent is then turned on in rotation for filtration through a series of four coke-breeze filters, with a fifth in reserve. The buckets when full, fall, and in falling, re-set a series of penstocks which stop the flow to a full filter, turn it on to another standing empty, and empty a third which has been resting full, so that intermittent filtration can be carried on day and night without attention.

The average results of analysis of samples by Mr. Dibdin, and confirmed by other analysts, are as follows:—

	Grains per Gallon.		
	Oxygen absorbed in 4 hours.	Free Ammonia.	Albuminoid Ammonia.
Crude Sewage .	2·028	3·778	0·212
Tank Effluent .	1·4	2·763	0·175
Filtrate . . .	0·388	1·705	0·078
Purification on Crude Sewage per cent.	80·9	54·9	63·2

"The whole of the suspended matter was found to be practically removed. Nitrous and nitric acids were also formed, the consistent manner of their production showing the satisfactory condition of works obtaining."

The filtrates were all fairly bright and clear, and fit to be at once discharged into a river or stream, even of relatively small volume; and none of them showed any signs of putrefaction or offensive secondary decomposition on keeping." (*Filtration of Sewage and Water.* Dibdin.)

In comparing these results with those obtained at Sutton, it will be seen (see *ante*) that the Exeter crude sewage is much weaker than the Sutton sewage, because the town is not

drained on the separate system, and probably contains a larger amount of subsoil water.

After having stood the test of an extended series of observations, bacteriological as well as chemical, a Local Government Board inquiry was held in November 1897, on application made by the Corporation for a scheme to treat the whole of the sewage of Exeter. The details of the scheme, as submitted by Mr. Cameron, are briefly these:— (1) Three grit chambers 15 feet square by 15 feet deep; (2) Six tanks, each 35 ft. 4 in. wide by 181 ft. 4 in. long, by 7 feet deep; (3) Eight filters, each 4 feet deep, and with a superficial area of 13,013 feet. These filters will be filled with broken surface clinker of a size to pass a $\frac{1}{2}$-inch, but not to pass an $\frac{1}{8}$-inch mesh. In addition to the works, it is proposed to utilise 20 acres of land for irrigation and treatment of storm-water, although it is contended that the effluent from the filter-beds will be of sufficient purity to be discharged into the adjoining stream. By automatic arrangements the rise and fall of the level of the sewage in the tanks will be utilised to ventilate the out-fall sewer, and other arrangements similar to those already described will be made for the aeration of the tank effluents, and the automatic filling and emptying of the filter-beds in rotation. The dry weather flow of the sewage will remain in the tanks forty-five hours, and with a rainfall of $\frac{1}{4}$-inch, seven hours; after which the storm overflows will come into operation. With the exception of two paper-mills, one tannery, two breweries, and one soap manufactory, no other trades contribute any liquid refuse to the sewage.

At the inquiry the scheme was most strongly supported in its engineering aspects by Mr. Henry Law; in its bacteriological aspects, by Dr. Sims Woodhead; and in its chemical aspects, by Dr. Dupré, Mr. Thudicum, Dr. Rideal, Mr. Dibdin, and others. Indeed, Dr. Dupré contended that the effluent at Exeter was twice as good as the worst at Croydon sewage farm, and, in respect to albuminoid ammonia, was better than the effluent from the Birmingham sewage farm, and much better than that of other sewage

farms. He further maintained that any sewage which could be treated on a sewage farm, could be successfully treated on the Septic Tank System, and that the latter possessed the great advantage of being practically independent of seasons and of rainfall.

It was elicited at the inquiry that at Yeovil, where the system has been tried, the effluent was not very satisfactory, but it was admitted that this was due to imperfect filtration, and working the filters at too great a speed. The Yeovil sewage, too, is much stronger than the Exeter sewage, so that the tank storage and area of filters only require modification to turn out a sufficiently pure effluent.

The population for which the Exeter installation is provided is 25 per cent on the present population of 37,580. The normal daily flow of sewage is 1,064,610 gallons exclusive of storm-water, and provision has been made to deal with this up to 5,724,000 gallons per day. The area of $2\frac{1}{2}$ acres will include the whole of the installation, grit chambers, tanks, automatic arrangements, and filters, and the nett cost is estimated at £14,000.

No opposition was raised by any other Sanitary Authorities down stream, nor by the Exeter County Council.

The advantages claimed for the system are :—

(*a*) The non-production of sludge.
(*b*) A tank effluent in the best condition for either irrigation or filtration.
(*c*) A filtered effluent of great purity.
(*d*) A process free from nuisance.
(*e*) Absolute reliability in working.
(*f*) A system within the reach of all communities, and practically free from working expenses.

Whether all these claims can be fully substantiated is somewhat doubtful, especially in respect to the sewage of large manufacturing towns. It is obvious that if the sewage is acid it must be rendered neutral, or slightly alkaline, by the addition of lime, or some other alkali, otherwise microbial action would be checked in the tanks and filters. Chemical precipitation must therefore still be found

necessary as a preliminary to filtration, and where it is necessary the precipitation tank cannot be replaced by the septic tank. Then, again, while the automatic gearing is very ingenious, it cannot altogether supplant supervision, because like all automatic gearing it may get out of order, and if supervision is required, it may prove cheaper in the long run to turn the sewage on to the filters, and empty them in rotation, than to adopt the gearing. Moreover the plan proposed for the ventilation of the outfall sewer could surely be dispensed with by the construction of an intercepting chamber, with fresh-air inlet, on the sewer before it discharges into the grit chambers, while the storm-water could more fitly be discharged from this chamber than rushed into the grit chambers. It could then be treated on a separate filter-bed, or osier-bed.

Apart, however, from the patents attaching to the septic-tank system, it certainly appears on the face of it, that this adaptation of the biological treatment of sewage commends itself for the purification of all sewage which can be treated on land, or by filtration, without chemical treatment. There is no doubt, too, that the grit chamber, and septic tank or dumb-well, in effectually getting rid of the sludge in an inoffensive way by hastening natural decomposition and liquefying all animal and vegetable solids, would be far preferable to the foul open screening tanks which are still so common, and are preferable even to simple straining, because the large percentage of purification which takes place in them would greatly lessen the amount of land laid out as a sewage farm, even where land can be obtained at a reasonable cost. But the tanks should be of a capacity equal to the twenty-four hours' flow of sewage, and if the sewers convey the rainfall as well, the storm-water should be treated on a specially constructed filter-bed or osier-bed.

The septic tank would also appear to possess considerable advantage over the bacteria tank or bed, as in the "Sutton process," in respect to first cost, much less liability to create nuisance, and because in low-lying localities, the "head," or fall which would be required for the filtration

through the bacteria bed, as well as the filter-beds, could very often not be obtained. Then, too, in constructing the tanks, there does not seem to be any reason why they should not be constructed at a very cheap rate for small towns and villages, provided the level of the subsoil water does not stand at within 8 or 10 feet of the surface. Coigning with bricks or rubble as in a well, with cemented brick buttresses at intervals on both sides, would not only support a framework for a galvanised iron roof covered with turf or soil, but would also support the sides. The bottom could be grouted, and cemented, or asphalted, and if curved, could be made to slope to a well at one end for any cleansing out which might be required at long intervals. If the subsoil happened to be porous, there would be continuous draining from a tank so constructed, but as there would be no endangerment of water-supplies, this would be an advantage rather than otherwise.

It is also probable that the adoption of the tank system will greatly lessen the cost of sewering in towns, because in many instances the enormous expense which is often entailed in bringing the whole of the sewage to one outfall, may be greatly lessened by the possibility of obtaining separate outfalls on reasonable terms; while as regards towns situated on tidal rivers, or on the sea-side, chemical precipitation works, and long reaches of outfall sewers, may be dispensed with. In respect to inland towns, the question of the supplementary adjuncts of specially constructed filters, or land treatment, by intermittent downward filtration or irrigation, will remain one of relative cost depending upon local circumstances. But whether the sewage of any particular locality must be treated first by chemical precipitation on account of the character of the liquid trade refuse, or on the bacteria bed, or septic-tank system, further treatment on biological lines is essential to satisfactory purification either by intermittent filtration or irrigation, or a combination of both.

Section III.—Treatment of Sewage in Rural Districts

The satisfactory treatment of village slops is often a very difficult question, partly because, in the case of old villages, the drains are so radically defective that pollution of air and water are in many instances alike common. The shallow road-drains, which were intended, when first laid down, to carry off the surface water, and which, for the most part, are generally constructed of common drain-pipes, or loosely laid bricks or stones, have been converted into common sewers by conveying into them the badly laid and open-jointed drains leading from almost every house or group of houses in the village. If there be a water-course near the village, the drainage discharges into the stream by one or several outlets, as the case may be. Should it happen, however, that the village is some distance from a stream, then it is found that the slops discharge into open ditches by the roadside, or into field-ditches in the immediate neighbourhood of houses, and thereby often give rise to filthy nuisances in every direction. This description, it is true, only applies to the worst-drained villages; but in almost all of them some of these defects are to be met with. Shallow, unevenly laid, and leaky drains are especially common; and as these are not only liable to pollute any wells which may be near them, but, in consequence of the want of proper means of flushing, permit of filth-accumulations which give off noxious effluvia, they are a source of constant danger.

And this description, it should be remembered, applies to villages in which water-closets do not exist at all, or are very rare, so that the whole of the nuisance may be said to depend upon the disposal of the slop-water. The question, therefore, at once arises whether in any given case a new system will be required, or the existing system improved to remove nuisance, or whether the slops can be satisfactorily disposed of in some other way. In compact villages, or villages of any size, a proper system of drainage is absolutely necessary, because the multiplication of dumb wells or cess-

pools in villages, as in towns, is always attended with danger, and ought to be avoided as much as possible.

If the drainage of a village is otherwise fairly satisfactory, and the drains discharge into a large stream which is not used for drinking purposes below the village, it may not be necessary to interfere, provided there is no nuisance at the outfall. If, again, the village drains into one or more field-ditches, which can be kept free from nuisance by periodical cleansing on the part of the Sanitary Authority, such a mode of disposal may not call for a more approved scheme. But in all cases in which there is nuisance at the outfall, or risk of polluting water used for drinking purposes, the sewage, if it be at all possible, should be purified by irrigation, or it should be filtered through a filtering area of sufficient size, and on the intermittent downward filtration system. In some cases the outfall drain may be carried by agricultural pipes alongside a field-ditch of lower depth, and the soil between will act as a ready filter. If land has to be purchased, an acre of ground properly drained and laid out would be quite sufficient to purify the slops and refuse-water of a village containing 1000 to 1500 inhabitants, provided the sewage is applied on the intermittent system and the subsoil is porous. Of course if simple irrigation should be carried out, more land would be necessary, but the ground should be drained and properly levelled, and in either case it would be of advantage to construct a septic tank, or tanks, large enough to contain the whole twenty-four hours' volume of sewage with grit chamber and storm overflow, as a preliminary, because less filtering area would be required.

When the volume of slop-water is comparatively small, the effluent from the tank may be occasionally disposed of by sub-irrigation drains, a plan which has been successfully adopted in my own district. These drains are constructed of common agricultural drain-pipes laid at a depth of not less than 12 in. from the surface, and with only a slight fall of about 1 in 100. If the ground slopes considerably, the drains must radiate, or be laid zig-zag from the tank, so as to obtain this slight gradient. If the subsoil is stiff, it is

advisable to dig out a trench about 2 ft. wide and not less than 1 ft. 6 in. from the surface, and fill in with gravel or sound ashes to a depth of 6 in. before laying the pipes, and then cover with soil. The pipes should be large enough to take the full flow of sewage *minus* any excess of storm-water, if the drainage is not on the separate system. The sub-irrigation drains should terminate in pits 4 to 6 ft. deep, filled with rubble, and covered with soil. This system of sub-irrigation lends itself admirably to the disposal of isolated country houses, or groups of houses, but in all instances it is essential to intercept from the tank or cess-pool by means of a ventilated inspection chamber with syphon-trap. It may be sometimes necessary to take up and relay the sub-soil drains on account of their becoming silted up, but judging from my own experience, this is rarely necessary, and as an instance in point I may mention that the sewage of an isolation hospital in one of my districts was disposed of by sub-irrigation on my advice in 1876, and that the drains were not disturbed till 1892, when the ground in which they were laid was required for the erection of an additional block, and the sewage was then conveyed on to some land which had been acquired for the extension of a neighbouring sewage farm. The subsoil was marl, and the sub-irrigation drains which were found to be working satisfactorily when taken up were laid in the garden, and no sub-draining was required. The site, which was on a slope, consisted of only $1\frac{3}{4}$ acres, and a good supply of water was found by sinking a well at the upper end close to the administrative block. Care was taken that there could be no pollution of the well-water, and this, of course, should receive special attention in all cases. This system may be used successfully in the gardens of country houses or groups of houses, provided the surface of the ground slopes away from the houses, and it is especially suitable for land which is reserved for pasture land.

Drainage schemes, as well as schemes of water-supply, for small towns and villages have all along encountered opposition, generally of the most strenuous kind, on account

of the incidence of rating. Outlying houses in the parish in which the small town or village is situated are rated on the same assessment basis as houses embraced within the drainage area, and the whole of the land is rated at one-fourth. Consequently, those living in the outlying parts of the parish oppose very strongly because they derive no direct benefit, and the small property-owners within the area frequently also oppose, simply because the rates will be increased. But the outlay for small drainage schemes is not so heavy in the great majority of cases as is generally believed, and in respect to compact villages with average outfall facilities, a complete scheme, including land, should not cost more than £1 per head of the population. As instances in point, the following may be quoted:—Brixworth, in the Brixworth Union, with a population of 1180 was drained in 1876-78 at a cost of £822, including an osier-bed of 1 acre; Spratton in the same Union with a population of 817 was drained in 1886 at a cost of £810, inclusive of one acre of land; Whissendine, in Rutland, with a population of 734, was quite recently drained at an outlay of £1000, including £140 for outfall and osier-bed of 1 acre; while East Dereham, Norfolk, with a population of about 6000, was also recently drained at a total cost of £4911, including the purchase, laying out, and draining of 4 acres of land for irrigation purposes (see *Practical Sanitation*, by G. Reid, M.D.)

Section IV.—Sanitary Aspects of the Water-Carriage System of Excretal Removal and Disposal

So much has been already said with regard to the evils resulting from collections of excretal matters in towns that at first sight the superiority of any system which prevents these accumulations would appear to be placed beyond dispute. But unfortunately the water-carriage system is by no means free from dangers, and these have been attended with such serious consequences that at first many were led to condemn it altogether. But it has long since been

clearly proved that the few important outbreaks of enteric fever which have been attributed to the water-carriage system, were due to faults in the system and not to the system itself. Indeed, the very fact that this disease has exhibited a remarkable decrease of late years, and especially in water-closeted towns, affords the strongest argument that the water-carriage system, as it is the cleanest, is also the safest, provided that house drainage as well as public drainage are carried out on sound sanitary principles, and receive proper attention as regards flushing. At the same time, there can be little doubt that the serious nuisance often complained of in respect to street ventilators, is more or less injurious to health, but if the dead ends of branch sewers were adequately ventilated as they should be, there need be no hesitation in closing up any street ventilators which are offensive. All this, however, has been discussed in the previous chapter.

With regard to sewage disposal, it must be admitted that sewage works or sewage farms which give off offensive emanations so as to be a source of nuisance to people living in the neighbourhood, or to passers-by, are also more or less injurious to health. But this is no argument against the system of irrigation or land treatment, when properly carried out, unless direct evidence can be brought forward to show that, even when the engineering and management are alike satisfactory, there is not only possible but actual risk to health. The only risk to health attaching to sewage farming is pollution of water-supplies by insufficiently purified effluents, and where such risk does exist, special precautions and constant supervision are always required. Apart from this risk, however, which applies less to land treatment than to any other method of disposal, it was at one time feared that entozootic diseases would be greatly propagated, no matter how efficiently irrigation might be carried out, and the late Dr. Cobbold's high authority gave currency to the belief. Dr. Cobbold, however, with rare scientific candour, and after careful investigation, afterwards stated that the fears which he

originally entertained had not been realised. Animals fed on sewage produce have not been found to be parasitically diseased, nor has any case of parasitism been detected in man which could be traced to the effects of sewage irrigation.

Alarmists, too, have not been wanting, who strenuously maintained that the milk of cows fed on sewaged grass is poor in quality, rapidly decomposes, and is unfit to be used. But so far is this from being the case, that there is an overwhelming amount of evidence to the contrary; and the butter as well as milk, yielded by cows fed on sewage grass, has invariably stood the test of numerous and careful analyses with the most satisfactory results. It need hardly be said that on a well-conducted sewage farm, no sewage is applied for several days before the grass is mown, so that it is always perfectly clean.

CHAPTER XII

SOILS AND LOCALITIES—THEIR INFLUENCE ON PUBLIC HEALTH

WHAT is called the Geographical Distribution of Disease, except where studied in respect to vast tracts of country and different climates, depends upon so many complex conditions, that it becomes very difficult to determine what may be the precise influence on health exerted by the purely physical features of soil or locality. We know, for example, that the class of diseases which characterise the tropical zone are the worst kind of malarial fevers, associated more especially with dysentery, diarrhœa, cholera, specific yellow fever, and hepatic affections, and that these fevers prevail with the greatest intensity in flat low-lying tracts of country, in the vicinity of marshes, the borders of lakes, the shores of the sea, and the banks of rivers. Indeed the geographical data, collected by medical writers, from the days of Hippocrates downwards, go to prove that every country is unhealthy in proportion to the extent of undrained alluvial or marshy soil which it contains, and that the excess of disease engendered is mostly of the remittent and intermittent febrile type. In the time of Sydenham, London was infested with epidemic intermittent fever and dysentery; but for years back, owing to the construction of sewers and a general system of deep drainage, cases of ague contracted in London are hardly known. Other towns, both in this country and France, such as Portsmouth, Bordeaux, and Rochefort, which were once the seat of malarial diseases, have in like manner been

rendered comparatively healthy. Even in the fen districts of Suffolk and Norfolk, ague, which was once so common, is now dying out, owing to the drainage improvements which have been instituted.

But when we come to study the distribution of disease in a country so limited in extent as Great Britain, and with climatic conditions so fairly uniform throughout, the process of eliminating other than purely local causes becomes exceedingly difficult. For example, we know that phthisis is much more prevalent in certain localities than in others; but in many of these districts it is found that heredity, consanguineous marriages, poor feeding, overcrowding, or industrial occupations, play a far more important part in the production of the disease, than topographical conditions. Indeed, it may be said generally that the purely artificial conditions, in and around dwellings, are of far greater moment from a public health point of view, in this country at all events, than geological formation or nature of subsoil. Nevertheless, geological conditions, in so far as they influence surface conformation, and the movement of water and air in the soil of different localities, are very important factors in the maintenance or impairment of health, and merit special attention in sanitary investigations.

Section I.—Topographical Conditions

These refer to the configuration and elevation of the surface, the exposure to certain prevailing winds or otherwise, and the relations to watersheds or river systems. The expressions, high and exposed, flat and low-lying, sheltered, sloping, undulating, and the like, have a certain, though varying, significance, in differentiating the various factors affecting the salubrity of any given locality. In hilly districts, the most unhealthy localities are enclosed valleys and ravines, where the air cannot circulate freely and must stagnate; while, as regards a comparatively flat district, the insalubrious spots are depressions below the level in which the subsoil water crops up to the surface. Vegetation has also an important

bearing on the health of a locality. Herbage on sound soils is always healthy, but isolated country houses and small villages, embowered among trees and low-lying, become unhealthy when the trees are so plentiful that they interfere with the free movement of air, and this unhealthiness is increased when the autumn leaves are falling. The banks of sluggish rivers, which are flooded in times of heavy rainfall, are always more or less unhealthy, and so too is the neighbourhood of flat estuaries, where the mists creep up in the evening, and hang in the early morning.

Section II.—Geological Conditions

These refer to the nature of the soil and the geological formation. Made-up soils become purified after a time by oxidation and the process of nitrification referred to in the previous chapter, but as a condition of purification the subsoil water must have a free outlet. No building should be permitted on sites of this description without making trial-holes and ascertaining whether all the organic matters have become decomposed; and even then the surface should be asphalted or concreted over, and free ventilation under the floors secured. Sandy and gravelly soils are always healthy except when they lie much below the general surface, and thus become water-logged. Clay and dense marls, on the other hand, are not so healthy unless the surface is undulating and there is a good fall in streams and brooks for the removal of the surface and subsoil water. Low-lying clayey soils are cold and damp, and favour the development of phthisis, rheumatism, and catarrhs.

As regards geological strata, it may be said generally that the granitic, metamorphic, and trap rocks are usually healthy. The surface conformation is hilly or undulating, the air is comparatively dry, and the rainfall rapidly runs off. So, too, with the clay slate formation; but water is often very scarce. In districts where the limestone and magnesian limestone formations prevail, the surface is generally undulating and healthy, but water is always hard

and often difficult to find. Of the different kinds of limestone, oolite is considered to be healthier than magnesian limestone; indeed goitre and calculus are more common in districts where this latter formation abounds than elsewhere. The chalk formation, when permeable, is very healthy, but where it overlies beds of clay it often becomes marshy and malarious, as in large tracts of America. The permeable sandstones and hard millstone grits are also healthy, and so, too, are gravels from which the subsoil water can drain freely away. But the principal factors which influence the salubrity of the subsoil of a locality are its power to absorb and retain heat, the amount and nature of the organic matter which it contains in relation to bacterial life; the character and movements of the ground air; and the nature, movements, and level of the subsoil water.

1. *Soil Heat and Temperature.* — Different soils vary not only in their power of absorbing, but also in their power of retaining or radiating, heat; and these properties, so to speak, are mainly influenced by the amount of water or organic matter which they may contain. As water is both a bad absorber and radiator of heat, soils which contain much water, as for example, damp, clayey soils, warm slowly and radiate slowly, and are therefore spoken of as "cold soils." On the other hand, dry porous soils, like sand, warm much more rapidly, and their power of retaining heat is much greater. According to Liebenberg of Halle, rich loam heads the list in its power of absorbing heat, while as regards power of retaining heat, the experiments of Schübler place sand first, then (in order), light clay, gypsum, heavy clay, clayey earth, pure clay, fine chalk, and lastly, humus.

With regard to radiation, it may be said generally that soils cool more rapidly than they absorb heat, and that their radiating power is much influenced by the colour of the surface and the thickness and growth of vegetation. While vegetation greatly protects soil against the absorption of heat, it makes radiation much more rapid. There is

no doubt too, that soil heat is increased in proportion to the amount of microbial action or fermentation going on in the interstices; as is illustrated on a large scale in a fermenting manure heap, so that, other things being equal, a rich loamy soil would be warmer than a poorer soil. It is obvious, therefore, that the soil temperature is rarely in accord with that of the atmosphere, for while the surface may quickly respond to small changes of atmospheric heat, the soil below the surface only follows great variations of temperature slowly. Födor of Buda Pesth was the first to point out that the surface of the soil is warmer by day and colder by night than the air, and that as the subsoil is influenced more slowly, it is colder in summer and warmer in winter than the superficial layers. Thus, he found that at a depth of $\frac{1}{2}$ to 1 metre the average maximum temperature is attained in August, and the minimum in January or February; at a depth of 2 metres (6 feet 6 inches), the maximum is in September and the minimum in April; while at a depth of 4 metres, the maximum temperature is observed in October.

In temperate climates, what is called the diurnal wave of heat from the sun's rays reaches to an average depth of 4 feet during the day and recedes during the night, but this, of course, varies with the nature of the soil and season. At a depth of 40 feet, the annual variation is not perceptible; at greater depths, the temperature gradient increases at the rate of 1° Fahr. for every 50 feet below the surface. The temperature of the soil at varying depths is shown by the temperature of water in shallow or deep wells, and in springs; but in making observations of the surface and subsoil temperature, it is necessary to make bore-holes or tubes of the required depth, and into these tubes pieces of wood are fitted to carry the maximum and minimum thermometers. When the instruments in the tubes are placed at the depth fixed for observation, the mouth of the tube is closed by a cap or plug. The observations are taken at a fixed hour daily, and the instruments re-set and returned to their position in the soil as speedily as possible.

2. *Micro-organisms in Soil.*—As has been shown in the previous chapter (see p. 327), the soil teems with micro-organisms, and the richer or more polluted the soil, the greater their number and activity. All forms of bacterial life are present, *micrococci* and *bacilli*, the former being more numerous near the surface, and the latter, in the deeper layers, but they are rarely found at a greater depth than 10 or 12 feet. As the necessary agents in nitrifying or mineralising organic matter, and thus converting it into appropriate food-stuffs for plant life, soil micro-organisms have been classified as *aerobic*, and *anaerobic*, or as oxidisers and deoxidisers; while so far as their functions in this direction are concerned, they are all designated as *saprophytic*. But there are also numerous organisms present, especially in soils polluted with animal organic matter, which are undoubtedly pathogenic in so far as they are found to be associated with certain diseases such as tetanus, anthrax, enteric fever, cholera and autumnal diarrhœa. All this, however, will be more fitly discussed in the following section. But whether saprophytic or pathogenic, or both, they are largely influenced, not only by the character of the soil, but by conditions of temperature and moisture.

3. *Ground Air.*—The nature of the ground air has been examined by many observers, and notably by Pettenkofer, Fleck, Födor, and Nicholls of America. Its composition and amount are very variable, but its chief ingredient is carbonic acid gas, due no doubt to the nitrification and oxidation of the organic matter contained in the soil. Occasionally it contains carburetted hydrogen, ammonia, and nitric acid, and in soils more or less damp, and where the water is hard, owing to an excess of sulphates, a small amount of hydrogen sulphide is usually found. According to Boussingault's experiments the amount of carbonic acid varies from 2·4 per 1000 volumes to 9·74 in soils which have recently been manured, while Pettenkofer and Fleck have found it to rise as high as 80 per 1000 volumes in gravelly soils at depths of from 5 to 13 feet. Indeed

Pettenkofer has proposed that the amount of carbonic acid gas should be taken as the index of the other impurities, but this is manifestly open to objection, because the more porous the soil, the greater the amount of atmospheric air present.

It has been observed that the amount of carbonic acid in ground air is sometimes greater than the amount of oxygen absorbed from the atmosphere, and this has been explained more particularly by Schlœsing as due to bacterial action. He ascertained that on aspirating air through earth containing putrefactive organisms, not only was the carbonic acid largely increased, but to an extent which showed that in addition to using up the atmospheric oxygen a considerable amount must have been abstracted from the organic matters, or by reduction of the nitrates into nitrites and ammonia. It is more than probable, however, that the excess of oxygen was obtained from the reduction of the organic matter, and that the nitrites and ammonia were the first products of mineralisation as shown in the previous chapter (see *ante* p. 328).

Lewis, Cunningham, Notter, and Frith have demonstrated by repeated experiments that the amount of carbonic acid in ground air is always increased by an increase in rainfall and temperature, while in dry cold weather it is reduced. If, however, the soil becomes too moist or saturated, the amount of carbonic acid is reduced owing to its absorption by water. Ground air always contains more moisture than atmospheric air.

In order to estimate the porosity of soils, or the total amount of ground air, the following is the plan adopted by Pettenkofer. A sample of the loose soil is rubbed down to a powder, but without crushing it, and dried at a temperature of 100° Cent. (212° Fahr.) A portion of it is introduced into a burette, which is gently tapped to force the air out of the interstices as far as possible. This burette is connected with another by means of an india-rubber tube provided with a clamp, and this latter is filled with distilled water. The two are then fixed side by side on the

same level, the pressure of the clamp is removed, when the water in the second burette flows into the first and gradually rises through the soil, until it appears as a thin film covering the top. The quantity of water which has thus passed from the second burette is then read off, and will represent the amount of air contained in the sample of soil, while the percentage of air in the soil will be obtained by the following formula: $\frac{a \times 100}{b}$, where a represents the amount of water used and b the quantity of dry soil.

It need hardly be said that not only does the quality of the air vary in different soils according to their nature, but it is constantly varying, owing to its continual movement, and especially where soils are dry and porous. These movements are largely influenced by temperature, barometric pressure, force and direction of winds, rainfall, and level of subsoil water. But there is another condition, which, though artificial, exercises even a more important influence, so far as health is concerned, than perhaps any of these. For example, during cold weather, a house which is well warmed, and has underground cellars or kitchens with no ventilated or impervious covering over the subsoil, is continually drawing air from the soil, and often from considerable distances. Thus the foul air from a cess-pool, according to Dr. Fyffe, was sucked into a house a distance of 27 feet, and coal-gas from leaky pipes has been found to travel long distances. Dr. Reid, medical officer of health for Staffordshire, has also recorded an instance of poisoning by carbonic oxide owing to air from a disused mine having found its way into the basement of a house in the proximity of the mine.

4. *Water in Soils.*—The water in soils is generally considered under two aspects, viz. the amount of water mixed with air to be found in any given soil, known as *moisture*, and that subterraneous lake or sheet of water which exists in all soils at varying depths, and known as *ground water*. The amount of moisture will depend on the nature of the subsoil, the amount of rainfall, the configuration of the ground, and the quantity of water derivable

from the ground water itself. The upper layers are kept more or less moist in the absence of rainfall by evaporation from the underground water, and by capillary attraction, which appears to be greatest in clays, and least in chalks, —sand and humus occupying a middle position. In their relation to water, soils and rocks are generally classed according to their permeability, and their capacities of imbibition and saturation. The proportion of water taken up per volume of soil is 70 per cent for humus, 60 per cent for clay, and 40 per cent for sand; while in respect to capacity for saturation as a water-bearing stratum, sandstone will retain 20 per cent of water, chalk 24, clay 19, and granite 0·1 per cent.

Moist or damp soils can be dried by draining, by opening the outflow if they are water-logged, as for example, by the removal of weirs on sluggish streams and rivers, which often render the flat lands through which they flow more or less water-logged, and by clearing out water-courses generally.

The ground water is in constant movement, and usually in the direction of the nearest water-course, lake, or sea. Its level varies from 2 or 3 feet to several hundreds, and depends upon the porosity or compactness of the soil, the amount of rainfall, and the dip and distance from the surface of impervious strata. Some soils take up large quantities of water. A loose sand, for example, may retain as much as 2 gallons per cubic foot, and ordinary sandstone may hold 1 gallon. Clay takes up 20 per cent, chalk 13 to 17 per cent, and humus 40 to 60 per cent.

The variation in the level of the ground-water or the depth at which it stands can be measured in wells, or by sinking trial-holes or bore-holes. Nothing need here be said concerning the delusions attending the "water-finder's" vocation.

The amount of moisture in soil is determined by drying a weighed quantity at 220° Fahr., and weighing afterwards. If the dried soil is placed over water in a bell jar, and again weighed, an estimate can be formed concerning its hygrometric properties.

Section III.—The Relations between Soils and Localities and Disease

As a general rule, it may be said that a persistently low ground-water level, say 15 to 20 feet, is healthy; that a persistently high level, say 5 to 3 feet, is unhealthy; and that a level which fluctuates suddenly and considerably is more unhealthy still, by reason of the fact that fluctuations in the ground level not only favour pollution of well-water, but by forcing impure ground air into houses they must exercise a most important influence on health.

But it is being made clearer every day that the relations of soil to disease depend mainly upon its characteristics and conditions as a breeding-ground for micro-organisms. Pettenkofer and others had long ago maintained that the soil exercised a specific influence on the development and spread of infective germs, but up till quite recently it was held by bacteriologists that so-called pathogenic organisms were not as a rule propagated in soil because they were crowded out or destroyed in the struggle for existence by the saprophytic organisms. For example, Koch and others failed to cultivate *Bacillus anthracis* in various kinds of soil, though they succeeded to a certain extent when they used sterilised soil. Flügge, while he admitted that pathogenic bacilli may find conditions on the surface of the soil favourable to their development, also maintained that they were easily overcome by saprophytes. But the recent researches carried out for the Local Government Board by Dr. Klein, Dr. Sidney Martin, Dr. Cautley, and Dr. Andrewes, go far to show that "soil and circumstance" as Sir Richard Thorne has so forcibly phrased it, do exercise a most powerful influence on the propagation, as well as control of pathogenic organisms, and that the old doctrine of filth and nuisance polluting air and water being prime factors in the causation of certain diseases, designated as filth diseases, still holds good. It is true that in respect to these diseases, the existence of a specific micro-organism is still assumed as the *causa causans* of each particular disease, but these

researches go to prove that their power or powerlessness for mischief is conditioned mainly by environment.

1. With regard to *cholera*, for example, Dr. Klein has noted that Koch's cholera vibrio, when cultivated outside the animal body under diverse conditions, is extremely prone to modification, and to such a degree as to be scarcely recognisable, culturally and physiologically, as the original vibrio, and that, by no conditions which he could contrive, was he able to induce the varieties to return to the original type. These investigations are instanced by Sir Richard Thorne as indicating that outside the animal body, the cholera microbe has no great tendency to breed there, and that they fully justify the measures in repression of the disease, which in this country have been attended with such marked success, namely, "so to deal with the invaded locality as to prevent or at least discourage, in air or in water, any foreign microbe upon which cholera may depend."

The outbreaks of cholera in England have so far demonstrated that it is mainly a water-borne disease, even when spread through the agency of oysters fattened on filth-polluted beds, but on the Continent, and in India, its relations to the movements of subsoil water, and soil temperature, have been noted by many observers to be so constant, that its diffusion by ground air seems to be clearly established. But whether air- or water-borne, continued investigation goes to substantiate the doctrine that apart from the environment of filth, the cholera vibrio becomes powerless for mischief.

2. *Enteric Fever.*—Assuming that Eberth's bacillus is the specific micro-organism of enteric fever, the recent researches of Dr. Sidney Martin go to prove that while the bacillus can be cultivated and live for months in filth-polluted soil which has been sterilised, its vitality ceases in from fourteen to twenty-three days in sterilised virgin soils, such as peat or sand, under precisely similar conditions of experiment. How far it is capable of competing with the saprophytes existing in unsterilised soil remains to be demonstrated, but numerous outbreaks of the disease lead to

the conclusion that fæcal pollution of soil infecting air or water, is essential to its vitality and development. Sir Charles Cameron has pointed out that in Dublin, where the disease is more or less endemic, its persistent occurrence can only be accounted for by displacements of ground air from a polluted subsoil, and that during the ten years 1881-91, the ratio of cases to population on a loose gravel soil was 1 in 94, while the ratio for those living on stiff clay was 1 in 145.

In respect to the outbreak of enteric fever which occurred in Chichester in 1894, Dr. Bulstrode, the Local Government Board Inspector, found that while no suspicion attached to water or milk, the whole of the gravel on which the town is built is riddled with privies and cess-pools, and that therefore the disease in this instance was air-borne. In spite of improvements in drainage and water-supply, enteric fever had been more or less endemic in Chichester for years back, doubtless owing to these soil-polluting receptacles, which had never been cleared away. Under the instructions of the Principal Medical Officer of the Local Government Board, Dr. Bulstrode has prepared a series of maps which illustrate the prevalence or diminution of mortality from fever in the registration counties of England and Wales, and which indicate generally the areas in which these soil-polluting conditions still prevail, or have been more or less successfully abated. (See Supplement *Local Government Report*, 1896-97.)

In towns where the water-carriage system of sewage removal is gradually replacing the system of movable receptacles, and midden ash-pits, statistics have proved conclusively that enteric fever, so far as the disease is endemic, diminishes as middens or privies are replaced by movable receptacles, and these again by water-closets.

So, too, in villages and rural districts, extended observation confirms the view that while outbreaks of the disease, as in urban districts, are generally water-borne, its endemicity or sporadic occurrence is due to filth accumulations, or to a filth-polluted subsoil, contaminating the air.

3. *Diarrhœa and Dysentery.*—As has been shown in Chapter III., autumnal diarrhœa is mainly due to similar conditions, and in this direction Dr. Andrewes has been carrying on some interesting experiments for the Local Government Board on the behaviour of certain anaerobic organisms which are found in the dejecta of persons suffering from epidemic diarrhœa, and also of those which are discoverable in the alimentary canal in health as well as disease. The results of these experiments, which have not yet been completed, will be awaited with interest. In warm climates, the prevalence of dysentery is largely due to subsoil conditions. A damp and porous subsoil, coupled with heavy rains and a high level of the subsoil water, is the essential characteristic of districts in which dysentery is most prevalent.

4. *Diphtheria.*—Although the relations of this disease to geological conditions are very varied, there is a general consensus of opinion that it is more or less associated with dampness of soil. Experiments have shown that pure cultures of Loeffler's bacillus, when mixed with garden soil kept constantly moist, will, under certain conditions of temperature (14° C.) and in the dark, retain their vitality for more than ten months. At a temperature of 30° C., however, and in a dry soil, they die out within a week. Dr. Adams of Maidstone maintains that the incidence of the disease in that town is influenced by the rise and fall of the subsoil water, and that when the normal sequence of rise and fall is disturbed, and there is stagnation at a high level, the prevalence of the disease becomes more marked,—the assumption being that the bacilli are aspirated or forced into dwellings, along with the ground air. But in all urban districts in which the disease is more or less prevalent, the part played by sanitary conditions is largely obscured, owing to the facility with which the disease spreads through school agency; indeed, there can be little doubt that the greater prevalence of the disease in urban than in rural districts during recent years is mainly attributable to the more rigid enforcement of attendance at school in towns.

In rural districts, on the other hand, in which the disease was at one time far more prevalent than in towns, the appearance of even a few cases amongst children attending school will generally suggest school closure, when the further spread of the disease is at once checked.

According to Sir Richard Thorne, the fact that the disease is so frequently associated with drainage defects, tends only to show that the power for mischief of Loeffler's bacillus is largely influenced by insanitary conditions, that, in short, whatever induces an unhealthy surface of the tonsils or laryngeal tract provides a suitable soil or breeding-ground for the bacillus.

5. *Malaria.*—It has frequently been matter for debate whether malarial fever is due to inhaling the air of marshes or drinking the water; but there is now a vast amount of evidence which proves conclusively that the air alone is frequently the medium through which the disease is conveyed, and the morbific agent is believed by many to be a specific germ known as the *Bacillus malariæ.* But whether the origin of the disease be microbial or not, the factors which are essential to its development are heat of soil, moisture, and air, and a certain amount of impurity which in all probability is of vegetable origin. In so-called malarious countries, outbreaks of the disease may be connected either with the rise or fall of the ground-water level. Obstructions to outflow of the ground water, as, for instance, during the construction of the Ganges and Jumna canals, have often been followed by widespread malarial epidemics; while epidemics quite as severe have been known to follow heavy rainfalls, succeeded by a rapid rise in the ground-water level, as at Kurrachee in Scinde, in 1869. Further, it has been noted that disturbances of the subsoil during the excavation of canals, the construction of dykes, and the reclamation of marshy land, by exposing the earth impregnated with organic matter to the energetic action of the sun, has often been known to be followed by increased prevalence of malarious disease. On the other hand, in the Lincoln Fens, where ague was once so prevalent, drainage removes the danger.

4. *Phthisis.*—Amongst the numerous valuable reports which the late Sir George Buchanan, in his capacity of Health Inspector, submitted to the Privy Council, there was perhaps none which excited greater interest at the time than his report "On the Distribution of Phthisis as affected by Dampness of Soil." In a previous investigation regarding the effects of improvements in drainage and water-supply, Dr. Buchanan had ascertained that in certain towns which had been improved in this respect, the mortality from phthisis had greatly diminished; and not only so, but the rate of diminution was found to correspond with the extent of the drying of the subsoil. This result, which was so far unexpected, led to the important inquiry above mentioned, and the principal facts connected with both may be briefly summarised as follows:—

In the first inquiry, it was found that wherever the drying of the subsoil had been effected, either by the construction of drain-sewers, or by special drains and deep storm-culverts, when the pipe-system was carried out, the mortality from phthisis had decreased from about 50 per cent downwards. In Salisbury, for example, the death-rates from phthisis had fallen 49 per cent; in Ely, 47; in Rugby, 43; in Banbury, 41; and in thirteen other towns the rate of diminution, though not so marked, was nevertheless noteworthy. On the other hand, it also became apparent that in certain towns, such as Alnwick, Stafford, Morpeth, and Ashley, where no drying of the subsoil had been effected, there was no reduction in the phthisis death-rate, even although the greatest possible progress had been achieved in the removal of filth. This was owing to the fact that in these towns impervious pipe-sewers had been laid down, without making any provision for deep subsoil draining, the storm-water being carried off in superficial culverts. In some towns, again, such as Penzance, where the subsoil was already dry, the phthisis death-rate remained stationary; and in others, where plans of drainage had been carried out the sanitary advantages, as regards phthisis, were nullified, because, as in the case of Carlisle, they were so low-lying

that the subsoil was at all times more or less water-logged. So far, therefore, the relation between dampness of soil and phthisis, as one of cause and effect, became highly probable, and Dr. Buchanan's second inquiry converted the probability into a certainty.

In this special inquiry (see *Tenth Report of the Medical Officer of the Privy Council*) the various registration districts in the three south-eastern counties of England, beyond the limits of the metropolis, were brought under detailed examination, and considered in two ways. Firstly, the true phthisis-rate of the population was ascertained, and due allowance made for the causes of the disease which were likely to influence the rate besides the nature of the soil; and secondly, the numbers of the population, in each district, that were found "living upon various kinds of soil, and under various topographical conditions," were also noted. The results of these two separate lines of investigation were then brought together, and statistically compared.

Without entering into any of the geological details, which are fully given in Dr. Buchanan's report, it may be said, generally, that the dampness or dryness of a soil depends partly on whether, if pervious, it is retentive of water, or, if impervious, the water can readily drain away. Again, it is obvious that pervious soils may present very different degrees of dryness or wetness, according to the elevation of the ground, and the dip of underlying impervious beds. Thus, a stratum of gravel or chalk, covering a sloping bed of impervious clay, is necessarily a dry soil, because the rainfall readily sinks to and flows along the surface of the impervious slope, whereas the same stratum in a valley may be actually waterlogged, although the depth of the stratum may be the same throughout. Bearing in mind, then, the topographical relations as well as the physical qualities of different soils, the following general conclusions, given by Dr. Buchanan as the result of his inquiry, will be at once understood:—

"(1) Within the counties of Surrey, Kent, and Sussex there is, broadly speaking, less phthisis among populations

living on pervious soil than among populations living on impervious soils.

"(2) Within the same counties there is less phthisis among populations living on high-lying pervious soils than among populations living on low-lying pervious soils.

"(3) Within the same counties there is less phthisis among populations living on sloping impervious soils than among populations living on flat impervious soils.

"(4) The connection between soil and phthisis has been established in this inquiry—

"(*a*) By the existence of general agreement in phthisis-mortality between districts that have common geological and topographical features, of a nature to affect the water-holding quality of the soil;

"(*b*) By the existence of general disagreement between districts that are differently circumstanced in regard of such features; and

"(*c*) By the discovery of pretty regular concomitancy in the fluctuation of the two conditions, from much phthisis with much wetness of soil to little phthisis with little wetness of soil.

"(5) The whole of the foregoing conclusions combine into one—which may now be affirmed generally, and not only of particular districts—that wetness of soil is a cause of phthisis to the population living upon it."

It is interesting to note that this new discovery in the etiology of disease, which in this country has been associated with Dr. Buchanan's name, had already been brought to the notice of the profession in America by Dr. Bowditch, of Boston, U.S. It would appear, however, that Dr. Bowditch's researches were not known in England until after Dr. Buchanan's inquiry had been finished; and although the priority rests with him, the credit of independently establishing causation of phthisis by dampness of soil as a general law in this country remains with Dr. Buchanan. But it would be unfair not to quote Dr. Bowditch's own remarks. In a very able and lucid address delivered to the Massa-

chusetts Medical Society in 1862, he submitted the two following propositions as containing the essential results of very extended inquiry:—

"First.—A residence in or near a damp soil, whether that dampness be inherent in the soil itself, or caused by percolation from adjacent ponds, rivers, meadows, marshes, or springy soils, is one of the principal causes of consumption in Massachusetts, probably in New England, and possibly in other portions of the globe.

"Second.—Consumption can be checked in its career, and possibly, nay probably, prevented in some instances, by attention to this law."

But in addition to phthisis there are several diseases, such as rheumatism, heart disease, and catarrhal complaints, which are intimately connected with dampness of subsoil, and it probably influences to a large extent the prevalence of other diseases.

While there can be no doubt that soil dampness and damp dwellings still play an important part as predisposing causes in the prevalence of phthisis, the discovery of Koch's tubercle bacillus, and the now generally entertained belief that the disease is essentially specific, and is spread by infection or by the ingestion of the milk or flesh of tuberculous animals, has largely modified the inferences drawn from the investigations of Buchanan and Bowditch. Indeed, Dr. Kelly, Medical Officer of Health for East Sussex, has expressed considerable doubts as to the intimate relation between dampness of soil and phthisis. He found that, during the decade 1861-70, the order in which phthisis prevalence had to be placed in several districts did not harmonise with that given by Buchanan for 1851-60, although there had been no change in the drainage of Sussex, and concludes that phthisis is most common in localities which are bleak and exposed as well as damp. Indeed, the presumption would appear to be that in localities where climatic and topographical conditions are closely similar, dampness of subsoil would declare itself as an important agent in the development or spread of all

diseases, which directly or indirectly affect the respiratory organs.

Concluding Remarks.—Although many valuable contributions have been made to the geographical distribution of disease in different regions of the globe, very little of a concise and well-defined nature has been achieved so far as regards this country. Indeed, Mr. Haviland may be said to be the only writer who has investigated this subject with any approach to completeness, and even his results are open to the objection that the statistics on which he based his inductions often applied to districts which were much wider than the town or village dealt with. Thus it generally happens that a small town only forms part of what is called a registration sub-district, and in this wider district the topographical and geological conditions may vary greatly in different parts. But many of Mr. Haviland's generalisations are based on statistics which apply to large tracts of country, and so far they claim for themselves a certain value, but even then they are intimately associated with conditions which are purely climatic. The diseases which are especially investigated in his painstaking work on the *Geographical Distribution of Diseases in England and Wales* are heart disease, cancer, and phthisis, and briefly summarised, his main conclusions are these:—As regards heart disease and dropsy, statistics showed that the highest mortality districts are always to be found in the most sheltered spots, and are generally those which lie nearest on the leeward side of the sheltering range. He attaches great importance to the purifying influence of sea-winds, and further states that agricultural labourers, owing to poor living, low wages, and having to turn out in the early morning when the dew is on the ground, the air chill, and the exhalations of the night are most noxious, are especially liable to rheumatism and all its complications. No doubt their liability to rheumatic disease is greatly increased by exposure to wet, and having to live in cottages which often have damp floors, and are built on undrained ground.

With regard to cancer, he found that in counties having

a high mortality from the disease, the tributaries of rivers flow from soft, marly, and easily disintegrated rocks into sheltered valleys through which the main rivers flow. During times of heavy rainfall these rivers invariably flood their adjacent districts, and have generally their waters coloured by suspension of alluvial matter. In all these respects the Thames valley is cited as a typical cancer field. Statistics also went to prove that cancer does not thrive on a high dry soil, but in view of the fact that cancer is prevalent in the higher lands both in Norway and Mexico, Haviland's deductions in respect to soil influences cannot be accepted without reservation.

With respect to phthisis his conclusions generally bear out those already stated in connection with dampness of soil, namely, that damp clayey soil, whether belonging to the wealden, oolitic, or cretaceous formations, is coincident with a high mortality from this disease. Basing his conclusions on the statistics of wider areas, he further states that coincident with sheltered positions there is a low rate of mortality, and that the easterly ridges of the south-east coast of England are characterised by a high mortality, owing mainly to their general aspect being favourable to the malign influence of the east wind. This also applies to the eastern counties having a high mortality, while the lower lands are characterised by clays of the Eocene period, especially the London clay. He further found that high elevated regions of non-ferruginous carboniferous limestone, coal, and silurian formations, form the sites of the most extensive series of high mortality districts, and especially instances Anglesey. On the other hand, he states as a general rule that a warm, fertile, and ferruginous soil is coincident with a low mortality from phthisis.

CHAPTER XIII

DWELLINGS AND SCHOOLS

THE vast importance attaching to the sanitary conditions of dwellings has already been frequently alluded to in previous chapters. Diseases arising from unhealthy site, from insufficient ventilation or overcrowding, from tainted or stinted water-supply, from defective drainage, or from accumulations of filth, are all of them associated with habitations which are faulty in their situation, construction, or management.

SECTION I.—SITE

In choosing a site, special attention should be paid to the nature of the soil and the general conformation of the ground. Soils in order of healthiness may be approximately classed as follows:—Those overlying the primitive rocks, clay slate, millstone grit and oolite, gravel and loose sands, chalk, sandstone, limestone, and clays. In cold and temperate climates, sands and gravels may be regarded as the healthiest, because they are warm and dry, but with cess-pools or badly-laid drains there is great risk of well pollution. The soil, if not dry, should be drained, and all hollows wherein water is likely to lodge should be avoided. For these and other reasons, the best situation for a house is on rising ground, with trees in the immediate neighbourhood, but not so close as to interfere with the free movement of the surrounding air. The aspect will very likely be influenced in great measure by the view to be obtained from the front windows, but it is preferable that a house should

face east or south-east, because in the morning the rays of the sun penetrate to the front rooms, and in the afternoon they cheer those at the back. When, on the other hand, a house faces south, the front rooms are overheated in summer by the rays of the noontide sun, while those at the back are deprived altogether of sunlight. Further, it is very essential in country districts that it be first ascertained that a good supply of wholesome water is procurable, and that there are no difficulties in respect to efficient drainage. If the subsoil is at all damp, it should be drained by suitable earthenware field-pipes, but care should be taken not to connect with house drains unless under strict precautions as to disconnection and ventilation. (See Chapter X.)

In towns, a great evil sometimes arises from building on rubbish containing vegetable matter which has been used to fill up the excavations made in brickmaking. Household ashes and road scrapings have been often used for this purpose, and it need hardly be said that such sites should not be built upon until a sufficient period has elapsed, generally three years, for the nitrification and oxidation of all organic matters. Indeed, if mixed fæcal matters have formed part of the refuse, the model bye-laws of the Local Government Board enjoin that all such contaminated soil should be cleared away before building operations are commenced. They also specify that in all cases the whole ground surface or sites of new buildings should be properly asphalted, or covered with a layer of good cement concrete, at least 6 inches thick.

In building on a site which has already been occupied, great care should be taken to make a thorough examination of the ground, so that no cess-pits, rubble drains, or old wells may escape notice. Every old drain should be taken up, all filth-polluted soil cleared away, and every pit thoroughly cleaned out and filled in with concrete.

In order to secure sufficient ventilation around new dwellings the bye-laws further make it incumbent on all Sanitary Authorities invested with urban powers to provide for a free air space in front, of at least 24 feet across, in

other words, that this should be the minimum width of new streets not exceeding 100 feet in length; if the street is of greater length and used as a carriage-way, the minimum width specified is 36 feet. They also provide for an open space at the back of each dwelling amounting to at least 150 superficial feet free from any erection above the level of the ground, with the exception of closet or ash-pit. Such space should extend the whole length of the building, and at no point should it be less than 10 feet across to the nearest boundary of any premises opposite. If the height of the building is 15 feet, the minimum distance across should be 15 feet; if the height is 25 feet, it should be at least 20 feet across; and if the height is 35 feet and upwards, the minimum distance should be increased to 25 feet.

Section II.—Structural Details

The arrangements with regard to drainage of subsoil, house drainage, closet accommodation, etc., have all been so fully described in a previous chapter (see Chapter X.), that it is not necessary to dilate further upon this part of the subject. Some further details may, however, be given with regard to points of construction as set forth in the model bye-laws:—

1. Except under certain prescribed circumstances in which timber framing is permissible, the outside and return walls of every dwelling must be constructed of incombustible materials, such as good bricks, stones, or other hard materials properly bonded and solidly put together with good mortar and good cement.

2. The footings of every wall must rest on solid ground, such as rock, or on a sufficient thickness of good concrete, and they should extend on each side to half the thickness of the wall and to a height of two-thirds of the thickness of the wall at its base.

3. If the whole of the building is above the ground level, every wall should be provided with a damp course of sheet lead, asphalt, vitrified stone-ware, or slates laid in

cement beneath the level of the lowest timbers, and not less than 6 inches above the ground level.

4. When there is a basement storey, it should be isolated from the surrounding ground either by an open area, or by constructing what is called a "dry" area. This consists of a thin outer wall bonded to the inner wall by stretching bricks, or iron ties, and with a hollow space between of at least $2\frac{1}{2}$ inches wide extending to a height of 6 inches above the ground. In this case two damp courses become necessary, one at the base of the wall, and the other at the

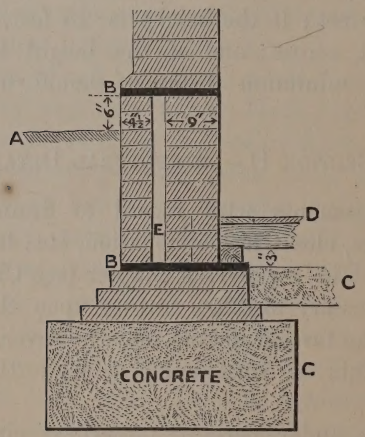


Fig. 32.—(From Annotated Model Bye-Laws.) A, Ground Level. B, B, Damp Courses. C, C, Concrete. D, Floor. E, Cavity between Walls.

level of the top of the cavity between the two walls (Fig. 32).

Although it does not fall within the scope of building bye-laws, it may be here pointed out that as much of the dampness in walls is due to driving wet, well-planned houses are now often built with hollow outside walls extending throughout. In single outside walls driving wet may be prevented by slating or tiling them, or by applying to the outer surface one or other of the several water-proof compositions which are well recommended.

5. The minimum thickness of all external or party walls

specified is 9 inches, and in large buildings it must be increased according to their height and length. Thus, if a wall does not exceed 30 feet in length, and does not comprise more than two storeys, it should be 9 inches thick for its whole height. If, however, the wall exceeds 30 feet in length, or comprises more than two storeys, it should be $13\frac{1}{2}$ inches thick below the topmost storey, and 9 inches thick for the rest of its height. Full regulations are given for thickness of walls of greater heights and lengths.

6. In order to prevent the spread of fire, all party walls should be continued up through and above the roof to form a parapet of a specific height, according to the class of building, and for the same reason no bond timber or wooden joists should be inserted in party walls. The roofs themselves should be made of slates, tiles, or other incombustible materials, and the gutters or shoots to carry off the rain-water should also be incombustible.

7. Wherever the lowest storey of a house has a boarded floor, it is very essential that there should be free ventilation between the wooden floor-joists and the surface of the concrete or asphalt which is laid over the ground to keep out the ground air. It is therefore specified that there should be a space at least 3 inches high between the asphalt or concrete and the joists, and that this space should be efficiently ventilated by the insertion of air-bricks in the outer walls. If such ventilation is insufficient, the air becomes damp and musty, and the joists and flooring are apt to be attacked with dry-rot.

8. Although unfortunately there is no prescribed minimum height for rooms, they should, as a rule, be at least 8 feet 6 inches high, even in the case of small rooms, and for average-sized rooms the minimum should be 10 feet. Power, however, is conferred by the Public Health (Amendment) Act, 1890, to make bye-laws with respect to height of rooms, as well as construction of floors, hearths, and staircases.

9. In order to secure sufficient light and ventilation, it is specified that every habitable room shall have at least one

window opening directly into the external air, and the total area of the window-space should be at least equal to one-tenth of the floor-space. It is further specified that every window should be constructed so that one-half, at the least, may be opened, and also that the opening may extend in every case to the top of the window. It will, therefore, be seen that this regulation permits of either double-hung sashes, French casements, or sashes hung on hinges or pivots.

10. Another important bye-law specifies that every habitable room which is without a fireplace and chimney, must be provided with special and adequate means of ventilation by a sufficient aperture or air-shaft, which should give a free sectional area of at least 100 square inches. (For further details as regards ventilation, warming, and lighting, see Chapter IV.)

Such is a brief summary of the more important structural details which are laid down in the model bye-laws of the Local Government, but unfortunately a great many sanitary authorities prefer to work under antiquated bye-laws, alleging as a reason that revision in accordance with the new model bye-laws would heavily handicap builders, especially in respect to the additional expense required for foundations and the thickness and height of party-walls. It need hardly be said, therefore, that jerry-building is still allowed free play in many towns, and even the erection of unhealthy back-to-back houses is not yet universally prohibited. It is unfortunate, too, that the great majority of rural districts throughout the country have no control over new buildings, except in respect to the provision of water-supply, so that glaring defects as regards house-construction, drainage, and closet accommodation are in a large measure perpetuated.

Section III.—Dwellings for the Working Classes

In constructing buildings for the labouring classes the great difficulty, encountered at the very outset, consists in providing the necessary accommodation with the requisite sanitary arrangements at a cost which will allow of a

sufficiently low rental. In towns the original cost is enormously increased by the high price of land; but even in country places, where a site can be procured at a cheap rate, the cost for the erection of a cottage of the humblest pretensions will entail a rental which many a labouring man can barely meet. Where the ground-rental is low, the cheapest and most commodious form of labourer's cottage is one without any upper storey. Thus, according to Mr. Allen, in his manual on Cottage Building, a cottage consisting of a living-room for general everyday use, a bedroom for the labourer and his wife, a bedroom for boys, a bedroom for girls, a small wash-house, a storeroom and closet, could be built for £100, provided all the rooms are on the ground-floor, and that two such cottages be ranged side by side, so as to be spanned by the same roof, and contained within four walls, forming a simple parallelogram.

Owing to the increased cost of materials, and the rise in wages, it is very likely that the above estimate would be found to be somewhat too low for the erection of similar cottages in the present day, but if built in blocks or pairs, I am credibly informed that good cottages with three bedrooms can still be erected for about £150.

In these plans, and in fact in almost all plans for cottage construction, the cubic space allowance is very limited, so that overcrowding to a greater or less extent is sure to prevail at times. Cottages which are scarcely roomy enough for a married couple with two or three children become occupied by much larger families, or the family increases in number year after year, while the bedroom accommodation remains the same. The initial space, therefore, should be ample enough to meet the requirements of, at any rate, moderate family increase; and when a number of such cottages are built in the same locality, they should be of different sizes, to suit small and large families alike.

In large towns the house accommodation for the labouring classes must necessarily be supplied in a great measure by what are called tenements, but in this case special attention should be paid to sanitary arrangements, such as

closet accommodation, water-supply, ventilation, and general cleanliness of premises, and a copy of rules or bye-laws should be prepared and handed to each occupant.

In the block system, the buildings, as a rule, should not exceed four storeys in height, and there should be a free open space on both sides of the blocks with a playground for the children. As few families as possible should be located on the same flat or landing. The staircases should be fire-proof, be at least four feet wide, and well lighted by large windows, and their walls and the walls of landings should be lined with glazed bricks or smooth cement. The closets and dust-shoots should be erected in projecting wings or offshoots from the main buildings, and a sink with water laid on should be provided for each dwelling. It is also necessary that there should be a sufficient number of wash-houses, and these are sometimes placed on the roof. If the blocks are built in quadrangles or squares, there should be free open spaces at the corners of the enclosed space to ensure sufficient ventilation.

In providing dwellings for the displaced population in large towns under the provisions of the Housing of the Working Classes Acts 1885 and 1890 (see Chapter XIX.), local authorities have experienced great difficulty in erecting houses at rentals which will pay a reasonable return on outlay, and yet be within the means of the poorest class of workmen. In Liverpool, for example, the experiment was tried of building blocks of tenements four or five storeys in height, but the rents charged were too high except for the well-paid artisan class. More recent dwellings, however, which appear to meet the requirements of the dock-yard labourers, are arranged on the flat system,—some only two storeys high, the lower flat consisting of two rooms and a scullery, with an enclosed yard and water-closet, while the upper, which has an independent entrance, is of the same dimensions, but with a balcony over the yard of the lower flat. This self-contained plan has also been adapted to blocks of flats of several storeys. Each dwelling has its own water-closet, and a plentiful water-supply. All storeys

are built on the same lines, only the intermediate and upper storeys have each a broad concreted balcony, while on the ground floor there is a yard. The rent of the flats on the ground floor is 3s. 6d. a week; of the first floor flats, 2s. 6d.; and higher than that, 2s. 3d.

Of equal importance with the construction of dwellings for the labouring classes is the far more difficult problem of repairing and improving the unhealthy abodes which, in town and country village alike, increase the annual rate of mortality to an extent that can hardly be estimated. It is to be hoped, therefore, that the carrying out of the provisions of the Housing of the Working Classes Act, 1890, will soon effect a marked improvement in this respect in many of our cities and large towns, for hitherto the difficulty of dealing with what is called "surface-crowding" has thrown great obstacles in the way of reaping to the full extent the advantages to be gained from lessening the indoor overcrowding. Demolition of old houses, the displacement of the population into blocks of model dwellings, or into houses put into serviceable repair, and the opening of new streets, are all necessary.

Concerning the duties of medical officers of health with regard to overcrowding and houses unfit for human habitation, see concluding Chapter.

Section IV.—Sanitary Inspection of Dwellings

1. *Diseases traceable to Sanitary Defects.*—There are so many diseases, and some of them so fatal, associated with sanitary defects in or around dwellings, that it is of the utmost importance that every medical practitioner, and above all every sanitary official, should be able to detect these hidden dangers, or direct how they may be discovered and remedied. Exclusive of new houses which have been erected in accordance with well-devised bye-laws, it is no exaggeration to say that in the vast majority of houses, and especially good-class houses, sanitary defects may be found which at any time may lead to the gravest consequences,

and when disease does break out the wonder often is that the inmates should have escaped so long. Minor disorders, such as languor, headache, so-called bilious attacks, dyspepsia, diarrhœa, and slight ulcerated sore throat, are frequently allowed to pass unheeded, or are treated as ordinary ailments; and it is not till disease of more pronounced severity occurs that the sanitary condition of the house becomes suspected, and the real cause is discovered. Tenants who have occupied an insanitary house for a considerable period often become acclimatised to the conditions, but new tenants entering such a house, or lodgers at health resorts, often fall victims to such disorders.

Apart from ailments which are connected with dampness of site, foundations, or of walls, such as rheumatism, phthisis, bronchitis, or other lung affections, the class of diseases which are associated with faulty house sanitation are essentially filth diseases, whether they originate *de novo* or are conveyed by befouled air or water. And among these diseases may be enumerated the following:—diphtheria, ulcerated sore throat, follicular tonsillitis, follicular stomatitis, croup, enteric and ill-defined forms of fever, diarrhœa and dysentery, erysipelas, carbuncle, abscess, pyæmia, hospital gangrene, and puerperal fever. There is no doubt, too, that the breathing of vitiated air, whether depending upon overcrowding, defective ventilation, or the entrance of sewer gas, not only induces phthisis, pneumonia, and other lung affections, but largely influences the spread of zymotic disease and the severity of all kinds of diseases, however they may have been originated in the first instance. Pneumonia is frequently engendered by impure air, and it is now generally admitted that this filth-pneumonia, as it may be called, is infectious, and occasionally becomes epidemic. Then, again, there can be little doubt that it is this influence which changes pleurisy into empyema, simple bronchitis into broncho-pneumonia, and which serves to explain the frequency with which lung affections are associated with various infectious diseases, such as small-pox, measles, whooping-cough, and enteric fever.

2. *Sanitary Defects in and around Dwellings.*—As regards the defects themselves, they are of every variety and extent, and many of them palpable enough. Damp foundations, damp walls, imperfect ventilation, windows not made to open, roofs dilapidated and out of repair, floors uneven, general uncleanliness, overcrowding—all these constitute nuisances which are especially common in the dwellings of the poorer classes in town and country districts alike. Then, if there is no sink inside the dwelling, there is generally a drain near the front or back door to remove the slops, which is so badly laid and trapped that foul smells are constantly given off, and these are often aggravated by other nuisances. In country districts, for example, pig-styes, byres, and manure heaps are frequently so close to the dwellings that the inside air is always more or less tainted. The closet accommodation, again, consists either of a foul privy, which, though sufficiently far removed, is so offensive that it cannot be used without risk, or of a privy and deep ash-pit close to the house and in dangerous proximity to the well. Indeed, pollution of the well-water from closets, leaky drains, or manure pits in farmyards is the principal cause of the majority of the sporadic cases of enteric fever which are met with in country districts, and of much of the diarrhœa which becomes more or less prevalent during dry and warm seasons. Apart from overcrowding, then, it may be said that the gravest dangers to health connected with the dwellings of the poorer classes in rural and small urban districts are external rather than internal, and therefore it is essential that in making a systematic inspection of such premises special attention should be paid to the surroundings. The points to be noted on a detailed inspection are the following:—Date of inspection; name or situation of house; name of owner and occupier; number of inmates; number of lodgers, if any; number of living rooms and sleeping rooms (if overcrowding is suspected, the cubic space of the sleeping rooms should be ascertained); state of ventilation (note whether all windows are in good repair and are made to open, and whether every sleeping-room not provided with

a fire-place has a ventilating opening of some sort in addition to window); conditions of floors and staircases (whether they are uneven or out of repair); condition of walls (whether damp or dilapidated); condition of roof (whether it lets in the wet); general condition of premises (whether clean and in good repair); general condition of yards or courts (whether clean and properly paved); condition of drainage and spouting (if any drain enters the house, note whether it is properly intercepted outside, also note whether outside drains are well laid and properly trapped, and whether roof and surface water is properly conveyed away); nature of water-supply (if from a well, note whether there are any sources of pollution near, such as deep ash-pit, privy, cess-pool of any kind, leaky drain, or manure pit—if water is suspected, have it analysed); nature, situation, and condition of closet accommodation (note whether closet is free from nuisance, whether there is a deep ash-pit in connection with it, whether, if not a pail-closet, it is situated at a safe distance from house or well, etc.); other nuisances (such as keeping of pigs too near dwellings, pig-wash cisterns, manure heaps, etc.)

In inspecting the poorer dwellings in the crowded parts of large towns, special attention should be given to the free space back and front, and back-to-back houses should be carefully examined and noted. The condition of the courts, streets, lanes, or back-yards should also be closely inspected in respect to paving, ventilation, lighting, and general cleanliness. The condition of outside closets, ash-pits, etc., should receive particular attention, while the details of the inspection of the houses themselves should be noted as already described, but special attention should be given to cellar-dwellings, and in all cases the water-supply and the condition and situation of water-cisterns should be carefully inquired into.

With regard to country mansions and the better-class country houses, the dangers to health, if not more numerous, are certainly more serious, and for the most part are connected with the drainage or water-supply. Indeed, it is no exaggeration to say that grave sanitary defects will be found

to exist in almost every country residence which has not been built or inspected within the last ten or fifteen years; and even in respect to new buildings it is lamentable to find that, owing to ignorance or neglect on the part of architect, contractor, or plumber, and sometimes of all three, the most serious blunders are still perpetrated in districts where no building bye-laws are in force.

One of the chief dangers in country houses whose sanitary arrangements have not been remodelled during recent years, attaches to the cess-pool and the drains leading to it. The cess-pool itself is generally some distance from the house, and is provided with an overflow which discharges into the nearest ditch or brook. In most instances it is usually completely covered up, and in any case is only cleaned out at long intervals, sometimes not for periods of years, and, to add to the danger, there is no disconnection, by syphon-trap and ventilated manhole between it and the house drains. The drains are frequently either rubble drains, sometimes huge brick culverts, or common tile drains; but, whatever their exact structure, they permit of free deposit, and are neither efficiently trapped nor ventilated. In close proximity to the walls, and sometimes under the floors, there are frequently supplementary cess-pools or catch-pits, intended to retain solid matters, which are kept covered up with close-fitting slabs, and are so seldom opened and cleaned out that their very existence becomes forgotten. Into this system of drainage are discharged directly the pipes from sinks and sculleries, the overflow pipes from baths, the drains from cellars, the soil-pipes from water-closets, and very often the rain-water pipes.

The water-closets are generally situated somewhere in the centre of the house, badly lighted, badly constructed, and without proper ventilation. The soil-pipes are unventilated, and very soon become decayed and perforated. Very often the cistern supplying the closet is filled by means of a force-pump; and the same cistern, which is rarely cleaned out, and from which there is an overflow pipe leading direct into the soil-pipe, also supplies the

water for drinking and cooking purposes. In addition to all these sources of danger, the well itself may be close to one of these leaky drains or cess-pools, or it may be near some outside offices of the worst form of privy or midden ash-pit, so that in any case it is constantly exposed to the risks of pollution.

In town houses of old construction the dangers to health are similar, though perhaps not so grave, inasmuch as the water used for domestic purposes is usually obtained from a public supply. But even this may become contaminated in the house cistern if the overflow pipe from the cistern, as often happens, discharges directly into the soil-pipe or the house drain, or if the same cistern directly supplies the water-closet. The drains, for the most part, are laid underneath the house, and are often found to be constructed of brick, and generally so leaky that the sewage percolates into the soil. In houses infested with rats it may be taken for granted that the drains are brick drains, or at all events that they are of very faulty construction. Even when drain-pipes have been used, they are frequently so badly laid and jointed that soakage into the soil becomes constant, and the inside air of the house always more or less contaminated. The closets, again, are generally of faulty pattern, and very improperly situated—it may be, in the centre of the house, on the landing, or too close to the bedrooms themselves; but in any case they are almost always badly lighted and ventilated. The soil-pipes, as in country houses, are usually inside the house, often very leaky, and seldom ventilated, nor are any other means of ventilation provided for the house drains. Moreover, the waste-pipes from sinks, baths, and cisterns, are often not properly disconnected, so that channels for the entrance of sewer air are to be found on every floor of the house, but especially in the basement, where, in addition to the leakiness of the drains, there are openings into them for the purpose of washing down the floors or draining cellars. These drain inlets are a permanent source of danger, because the traps are often bell-traps, from which the water evaporates, leaving practically untrapped openings; or if the

water does not evaporate, the pressure of sewer gas is so great that the water becomes tainted, and is constantly giving off foul emanations. Another common source of danger depends upon the direct connection of the overflow pipe from the soft-water tank or well with the house-drain, and which not only taints the water in the well, but becomes a channel for the entrance of sewer air into the house. Sometimes it happens that foul smells are detected in parts of a house where there are no drains or inside pipes discharging into them, and in these cases it is generally found that the foul air travels along rat runs, under floors, or behind skirtings; or it may be conveyed along the pipes containing the bell-wires; or it may find an entrance through the windows, from an adjacent rain-water pipe which is directly connected with the sewer. Of course foul smells in a house do not always indicate the entrance of sewer air, but they should never be tolerated a single day until the cause is ascertained and removed. Sometimes they are caused by the decaying body of a dead rat or mouse under the flooring, by dry rot, or, in rare instances, they have been found to proceed from some filthy paste used in papering the walls; but as a rule they point to defective drainage or escape of sewer gas into some part of the house.

3. *Mode of Inspection.*—In making a detailed examination of the sanitary condition of a large house, it is advisable that either an experienced builder, whose practical knowledge can be relied upon, or a sanitary engineer, be called in; and if there are plans of the house and drainage in existence, these should be obtained. In order to make the examination as thorough as possible, arrangements should be made to have the drains previously opened in several places, and concealed pipes and other fittings exposed to view. If the main drain is found to pass under the house, and to be badly laid or constructed, the instructions should be to have it taken up and relaid. Should it appear to be in good condition, it should then be tested as to its soundness, which is done by stopping it up at its lower end and filling it with water, and noting whether the water sinks or

not, and at what rate. To test whether there are any deposits, a large volume of water should be poured down at the water-closet or sink, and if this appears foul and thick at the lower opening, the drain is condemned as one of deposit. By noting the time which intervenes before the rush of water appears at the lower opening, an approximate idea may be obtained of the velocity of flow, or this may be determined with greater precision by pouring down some lime-water, and timing the flow. Leakages in the soil-pipe or in the closet fittings for the escape of sewer gas, may be detected by first pouring down some oil of peppermint and afterwards some hot water at the closet or sink, but by far the best plan is to blow up at the opening made in the drain the smoke from an asphyxiator or smoke-testing apparatus. If the soil-pipe is ventilated, it is essential that it should be stopped up at the top when the smoke test is applied, but not till after the smoke is seen issuing out of the top of the soil-pipe. For ready testing, an opinion as to the condition of the drainage can often be given at short notice, by lighting and inserting a smoke-rocket into the drain opening in a bell-trap, or by mopping out an ordinary gully trap, and inserting the lighted smoke-rocket into the trap, and then effectually closing the trap. Another plan is to plug up the drain at the opening and apply the water test. If the water oozes away, this will show that the drain is leaky. It is always advisable to uncover and examine the junctions of all soil-pipes with the drains, and also the connections with water-closet pans.

The next point to be determined is whether or not the house drain should be intercepted. As already shown in the bye-laws laid down for the drainage of new houses, this disconnection of the house drain by trapping, and providing a ventilating opening on the house side of the trap, is often of the utmost importance, and it can readily be carried out in all cases, either by providing a ventilating pipe if the house is close to the street, or a simple open grating if there is sufficient space. (See also Chapter X.)

Before leaving the basement, all traps and branch drains

should be carefully examined, and a careful search should be made for cess-pools, if the existence of any is suspected. The condition of the flooring should also be noted as to dryness or otherwise, and the ventilation of all parts of the premises should be inquired into. Any water-closet on the basement which is found to be in the centre of the building, or to abut against any inside wall, should be condemned. Such closets are badly lighted and ventilated, and the drains leading from them are usually very defective, and liable to be choked up. If there are no underground cellars or basement, inquiry should be made as to whether the space beneath the floor is sufficiently ventilated, and whether there are any signs of rot. The dust-bin or ash-pit, and any outside offices, should also be examined, and if the ash-pit is found to be large and deep, it should be filled up to the ground level and properly paved.

The details to which attention should next be directed are those connected with water-closets, sinks, baths, etc. If the closet is in the centre of the house, or abuts against an inside wall, there can be no doubt of the faultiness of the arrangement. But even when the closet abuts against an outer wall the soil-pipe generally leads down inside the house into the drain, and not infrequently is taken through cupboards or larders. The track of the pipe should be exposed to view, and its soundness tested, by means of filling it with water, or by the smoke test; but it is advisable to recommend, in any case, that the soil-pipe should be carried outside, and be ventilated by a pipe of the same dimensions extending to above the eaves. Small ventilating pipes, of about $\frac{3}{4}$ in. or $1\frac{1}{2}$ in. in diameter, are practically of little use, and often become choked up. The woodwork and fittings of the closet should next be examined, and any overflow pipe from the safe should be made to discharge outside. Should the closet-pan and fittings be found to be obsolete, or in other respects defective, new fittings will be required. If the pipes from sinks, lavatories, and baths are not disconnected—and it is seldom found that they are, except it be in new houses—instructions should be given to

have new fittings, with properly trapped waste-pipes carried outside and made to discharge on to trapped gratings communicating with the drain. Rain-water pipes which are found to be directly connected with the house drains should also be disconnected, and any found passing inside the house should be carried outside. Indeed, in respect to insanitary houses it is generally found necessary to remodel the whole system of house drains and sanitary fittings.

The cisterns which supply the closets should next be examined, and it should be ascertained whether these supply the drinking-water as well. If the water is stored in a large cistern under the roof, and is found to supply any taps, each closet supplied from this cistern should be provided with a small waste-preventing cistern, or steps should be taken to provide an independent supply for drinking and cooking directly from the main. The cistern itself should be examined as to cleanliness, and the overflow pipe, which is often found to lead directly into the soil-pipe, should be carried outside. Soft-water cisterns or tanks should also be examined, because it frequently happens that the overflow pipe is directly connected with the house drain. This pipe should be properly intercepted by a ventilated intercepting syphon-trap.

In all houses provided with a public supply the use of well water should be condemned, because, although it may be found to be fit for drinking purposes, the risk of pollution is always greatly increased in towns, on account of neighbouring drains and sewers. In country districts special attention should be directed to the water-supply, and any deep ash-pits, midden-privies, or cess-pools near wells should be removed, and the drains examined. If the water is pumped up by means of a force-pump into a cistern, for the purpose of supplying the closets, it will generally be found that the cistern also supplies the housemaid's sink, and that at this tap the water-bottles, as well as bedroom utensils, are usually filled.

If an entire new system of drainage is deemed necessary, all old drains, polluted subsoil, cess-pools, etc., should be

cleared away, and the details and sanitary appliances generally should be carried out as already described in Chapter X.

Although much improvement has been made of late years in the sanitary arrangements of dwellings, it should be laid down as a rule by every tenant in search of a house, that he should have the sanitary condition carefully inquired into, and any defects removed, before he takes possession. In London, Edinburgh, Gloucester, and several other large towns there are Sanitary Protection Associations which undertake such inspections, and repeat them at stated times for a fixed fee or subscription; but it would be a wise policy on the part of Sanitary Authorities throughout the country to undertake these duties themselves, and not limit their functions to the removal of actual nuisances, without interfering with many defects which only become declared nuisances when disease breaks out. At a good many watering-places such certificates have been granted by the Sanitary Authorities for some time back, and it is very gratifying that the demand for them is becoming much more general on the part of lodging-house keepers, and hotel keepers. The following are the requirements in force at Eastbourne as drawn up by Dr. Willoughby, the Medical Officer of Health, and the certificate is signed by him. (See *Journal of State Medicine*, October 1897.)

1. Drains: to be of glazed stone-ware or cast-iron pipes having a minimum internal diameter of 4 inches: to be laid in straight lines with regular and equal fall of not less than $1\frac{1}{2}$ inches in 10 feet and to be bedded in concrete: to be provided with intercepting syphon, manhole, and through ventilation. All joints to be proved sound by the "water test."
2. Soil-Pipes: to be outside the house: to have a minimum internal diameter of not lest than $3\frac{1}{2}$ inches: to be carried up full size to a sufficient height, and to have the fewest possible bends and angles: closet connections are to be drawn lead T-pieces.
3. Ventilation of Drains: drain ventilation to consist of inlet, close to syphon, and outlets, at the heads of the system; the soil-pipes to be additional to these outlets unless the former

are at the heads of the drain system. The joints of soil and ventilating pipes to be proved sound by the smoke machine.

4. WATER-CLOSETS: closet seats to be hung: lead safe, with outgo into open air having hinged flap at its end, to be laid over the whole of the floor space under the closet casing: walls under closet seats to be properly plastered. Traps to be of approved self-cleansing form. (Pan closets and D-traps entirely prohibited.) Anti-syphonage pipes to be provided if the closets are in tiers. Such pipes to be united, and to terminate in soil-pipe above the topmost closet connection.
5. HOUSEMAID'S SLOP SINKS: where they exist, to be constructed in every respect as water-closets.
6. CLOSET FLUSHING SERVICES: to be absolutely distinct from domestic service: $1\frac{1}{4}$-inch pipe and valve to be fixed if the hydrostatic head be under 10 feet: 1-inch pipe and valve may be used for heads of 10 feet and upwards.
7. DOMESTIC WATER-SUPPLY: a supply from the main direct, with or without special cistern, to be provided. The main tap to be over a sink and marked.
8. WASTE PIPES: to be trapped immediately beneath the fittings and to discharge over, or into gully-traps in the open air.
9. RAIN-WATER PIPES: to discharge over or into gully-traps.
10. YARD TRAPS: to be gully-traps of round-way form, and no such traps to be inside the house.
11. DUST-BINS: to be either brick built rendered inside, provided with doors and coverings and floor to be above ground level, or galvanised iron tubs with covers.
12. PLAN: a plan of the drainage system, $\frac{1}{8}$ scale, to be deposited at the Sanitary Department.

SANITARY CERTIFICATE

I, the undersigned, being the Medical Officer of Health for the Borough of Eastbourne, DO HEREBY CERTIFY

(1) *That the sanitary fittings of the dwelling-house known as*

*in the said Borough were on the*_____*day of*_____, 189__, *inspected by*_____*the*_____ *for the said Borough;*

(2) *That on the*_____*day of*_____, 189__, *the underground drains and all soil and ventilating pipes in connection therewith were tested by the said*_____*and found sound; and*

(3) *That on the*_____*day of*_____, 189__, *I personally inspected the aforesaid premises and satisfied myself that the sanitary fittings complied with the Regulations adopted by the Corporation with respect to the issue of this Certificate, and were in good working order, and that the aforesaid dwelling-house was in a GOOD SANITARY CONDITION.*

CONDITIONS OF ISSUE

This Certificate will become void and forthwith be cancelled—

(1) *If any variation be made in the drainage or sanitary arrangements now existing without the consent or knowledge of the Corporation.*

(2) *If any defect be hereafter found in the drains or sanitary fittings.*

This Certificate to be in force for three years, and its re-issue to be subject to the drainage and fittings being proved to be sound and in good working order.

By Order of the Borough Sanitary Committee.

Dated this_____day of_____, 189__.

TOWN HALL, EASTBOURNE. MEDICAL OFFICER OF HEALTH.

Section V.—Schools and School-Houses

Next in importance to sanitary dwellings, so far as the health of the community is concerned, is the sanitary condition of schools whether public or private. Indeed, the numerous boarding-schools throughout the country are dwellings in the strict sense of the word, which should be even more completely safeguarded than ordinary homes, because any sanitary defects which may exist are far more likely to act injuriously on inmates with varied constitutions, coming mostly from healthy homes, and for terms interrupted by long holidays, than on the households of the masters and mistresses themselves. It is, therefore, much to be regretted that in spite of various attempts to secure legislative interference, no measure has yet been passed to place such schools under proper supervision so that they could be officially inspected and certificated as to sanitary condition. It is true that, at most of the large public schools, such supervision is put in force by the governing bodies in respect to the boarding-houses attached to them as well as the school buildings, and a good many private schools are also certificated, but the vast majority of them have never been specially inspected or remodelled as to sanitary fittings, drainage, and water-supply. But apart

from sanitary condition, inspection of all private schools is also rendered necessary to prevent overcrowding in bedrooms, dormitories, and class-rooms, and to ensure that the premises throughout are well-warmed, well-ventilated, well-lighted, and kept scrupulously clean. With regard to the cubic space of bedrooms and dormitories, an average of 800 cubic feet should be aimed at, though this is far in excess of what is generally found to prevail, while in respect to class-rooms the minimum, even with a good system of warming and ventilation, should not fall below 300 cubic feet, nor, for studies, 400 cubic feet. Cubicles in dormitories are objectionable, not only from a disciplinary point of view, but because they interfere with free ventilation, and tend to untidiness and want of proper cleanliness. In inspecting girls' boarding-schools, I have seen cubicles arranged by means of curtains drawn on rods resting on supports. These ensure privacy while dressing and undressing, but so soon as the pupils get into bed the curtains should all be thrown back, and kept thrown back during the day. Such an arrangement, however, would obviously never answer for boys. In boys' boarding-schools or school-houses, a dressing-room with lavatories and bath-rooms should always be provided for undressing after football, etc. Dormitories should only be used for sleep. The combination of sleeping-room and study for boys is most objectionable in every way, and even in otherwise good schools some of these dens are more like prison cells, only that they are not kept so clean and orderly. For girls, this combination is not so objectionable, provided the room is sufficiently large, and is well lighted, warmed, and ventilated.

No parent or guardian should send any pupil, whether boy or girl, to a boarding-school, without personally inspecting the house, and being fully satisfied as to sanitary condition by a properly attested certificate. The dormitories as well as class-rooms should be visited; the bed-clothes, bed-linen, and mattresses looked to; and the dietary inquired into. The bathing accommodation, the arrangements for healthy exercise and training, the accommodation for clothes

in the shape of separate sets of drawers, and separate wash-hand basins and utensils, are all of them important desiderata which should receive attention, as well as the curriculum and teaching, which are generally considered as the sole matters of moment.

With regard to public elementary schools, so much has already been described concerning methods of ventilation and lighting that little more need be added. Public elementary schools, which may still be erected, or are in course of erection, have to be planned and constructed in accordance with the published rules as contained in Schedule VII of the Education Department Code of 1897. The great difficulty is in satisfactorily improving the vast numbers of denominational schools which still exist in all parts of the country. The class-rooms, and general sanitary arrangements, are often found to be very defective, and though these are matters which come more directly under the cognisance of the Departmental Inspectors, they also concern the sanitary officials, and especially the condition of the outside offices and the question of water-supply. In towns with a proper system of drainage, and provided with a public water-supply, trough-closets, as already described in Chapter X., are to be preferred, while in rural districts some form of dry closet or dry privy, together with efficient scavenging, should be insisted on.

In the rules laid down by the Education Department, the following table shows approximately the number of closets needed :—

	For Girls.	For Boys.	For Infants.
Under 30 children	2	1	2
,, 50 ,,	3	2	3
,, 70 ,,	4	2	3
,, 100 ,,	5	3	4
,, 150 ,,	6	3	5
,, 200 ,,	7	4	6
,, 300 ,,	8	5	7
		Urinals in proportion.	

It is also laid down that each closet must be not less in the clear than 2 ft. 3 in. wide, nor more than 3 feet, fully lighted and ventilated, and properly screened or supplied with a door. More than one seat is not allowed in any closet.

With regard to details of warming, lighting, and arrangement of desks, see Chapter IV.

CHAPTER XIV

HOSPITALS

In large towns the position of every hospital must primarily depend on the distribution of the population, or part of the population, whose wants it is intended to relieve, and hence the choice with regard to site is often very limited. Apart, however, from this restriction, there are certain considerations which ought always to influence the selection of site. For example, the future hospital should be erected in as airy and open a space as can be obtained, preference being given either to the outskirts of towns or to their largest interior unoccupied spaces. In this country an acre per 100 patients has been held to be sufficient, but a good deal will depend on the size of the hospital. Any defect in airiness of site must be compensated by increased floor and cubic space.

No doubt, the most healthy site for a hospital is in the open country, with a dry and porous soil, and slightly raised above the plain to facilitate drainage, but even a stiff clayey soil can be made perfectly healthy if proper precautions be taken in asphalting or concreting the foundations, and in providing plenty of free ventilation beneath the ground-floors by building on arches. While shelter from the cold north-easterly winds is desirable, it is an error to build hospitals on the face of a steep slope, or in any situation where there is an impediment to a free circulation of the air. Whether in town or country, the blocks should, if possible, be so arranged in a north-east

and south-westerly direction, that the ward windows on each side should face south-east and north-west respectively.

In cities and large towns, hospitals, for the sake of convenience, must be erected in central localities, but for many of these, convalescent homes in the country, or at the seaside, are now being provided, and with marked advantage to the patients.

It is now generally admitted that, when large hospitals are rendered necessary, they should approximate as much as possible to the sanitary conditions which can only be ensured by detached buildings. The application of this principle has resulted in the construction of hospitals on the pavilion system—a system which accommodates itself to almost any site, if sufficiently large, and to any number of patients.

Section I.—Pavilion Hospitals

In this description of hospital, each pavilion may be regarded as a separate hospital, and the impurities of every single ward are cut off from the other wards. The pavilions are united by a corridor for administrative purposes and for convenience, but are so arranged that a free circulation of air can always take place between them. In its simplest form a pavilion would consist of a single ward, with the necessary additions for administration. More frequently, however, it consists of two wards, one above the other, and, in some instances, of three wards, as in the Marine Hospital at Woolwich. Three-storied pavilions are objectionable, because unless special precautions are taken, their height necessitates a lofty corridor to unite them, and induces stagnation of the air. With two-storied pavilions, on the other hand, the corridor need only be half the height of the pavilions. In large hospitals, such as the Herbert Hospital, the pavilions may be united in twos, end to end, with the corridor running between them, the staircase being, as it were, strung on to the corridor. But care must be taken that staircases or lifts should not act as air-shafts, by which the air from wards below can communicate with wards above.

Corridors, therefore, should be freely ventilated by cross ventilation, except where a system of mechanical ventilation is adopted. The distance between the pavilions should be at least twice their height. At the new General Hospital,

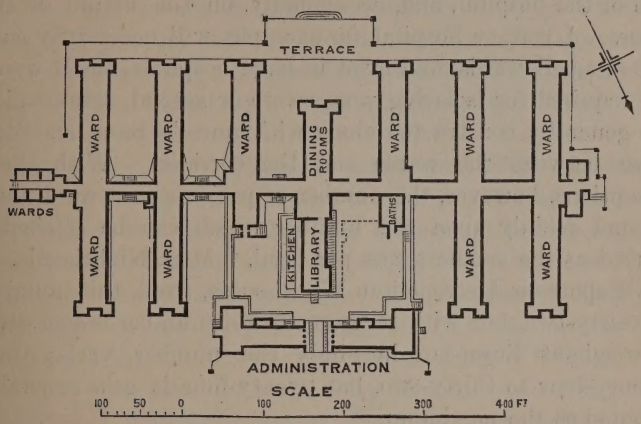


FIG. 33.—General Plan of Herbert Hospital, Woolwich. (After GALTON.)

Birmingham, designed by Mr. Henwood, the buildings are arranged in long and short blocks to prevent overshadowing. The administrative and service departments are centrally placed, and two hydraulic lifts are provided there for the top

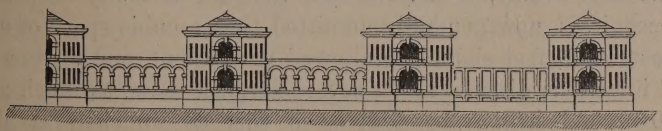


FIG. 34.—Sketch of the end of the southern Pavilions of Herbert Hospital, showing the elevation of the Corridor. (After GALTON.)

(kitchen) floor. These lifts are used for the conveyance of patients in beds or wheeled chairs, food-trolleys, etc. The corridors are closed, but by means of double ceilings and openings between, free circulation of air is secured.

The basis or unit of hospital construction is the ward. The conditions which determine the size and form of a ward are the following:—

1. The number of patients which it should contain.

2. The floor and cubic space allowed to each patient.

3. The arrangements for warming, light, ventilation, and nursing.

The number of patients in a ward will depend on the size of the hospital, and, occasionally, on the nature of the cases. A cottage hospital, for example, will necessarily consist of small wards, and even in large hospitals, small wards are required for isolating very severe or special cases, which are generally constructed along with nurse's room and day room between the wards and the corridor. With these exceptions, however, the number of patients in a ward must depend mainly upon the number which can be efficiently nursed at the smallest cost per head. Miss Nightingale, in the Report on Metropolitan Workhouses, fixed this number at thirty-two, but with severe cases this number is excessive. Throughout European hospitals the number varies from twenty-four to thirty-two, but twenty-four is now generally adopted as the maximum.

One of the most important questions attaching to hospital construction is the amount of floor and cubic space which should be allowed to each patient, and there is scarcely any question concerning which there has been so much discrepancy of opinion. Without entering into the details of this controversy, it may be said that for ordinary hospital cases it is now generally admitted that a cubic space of at least 1200 feet should be allowed per patient, and for cases of infectious disease, or for severe surgical cases, as much as 2000, and it may be doubted if this be sufficient at all times.

On the superficial area per bed will depend the distance between the beds, the facilities for nursing, and the conveniences for ward administration. This, like the cubic space, has been variously estimated. Thus, in St. George's Hospital it is only 69 square feet; in St. Bartholomew's it is 79; in the Herbert Hospital, 99; in the Netley Hospital, 103; in Guy's, 138; and in the new St. Thomas's Hospital, 112. In the new General Hospital at Birmingham it varies from 104 square feet to 107 in the general wards, to 130 in

the special surgical wards. For all nursing purposes, Miss Nightingale maintained that at least 90 square feet should be allowed per bed, and this amount, according to Sir Douglas Galton, should be accepted as a minimum. Where medical schools are attached to hospitals, an extra allowance must be allotted for the requirements of clinical teaching. The space must also be greatly increased in fever or lying-in wards. The height of an average-sized ward should be 13 to 15 feet.

For providing sufficient light and for maintaining purity of the air, much depends on the width of the ward. Experience has shown that this should not be less than 24 feet, and not more than 30 or 35. In the new Leeds Hospital it is 27 feet 6 inches; in the new St. Thomas's, 28 feet; in the Herbert Hospital, 26; and in the new General Hospital, Birmingham, 26, to 26 feet 9 inches.

The ventilation of each ward should be entirely independent of the others, and to effect this, cross-ventilation by means of open windows, aided by air inlets, extraction-flues, and one or two ventilating fire-places, according to the size of the ward, is deemed to be the most efficient. In the summer months, when fires are not required, the windows should always be kept more or less open, except during rough, blustering weather. In hospitals mechanically warmed and ventilated, such as the Victoria Hospital, Glasgow, and the new General Hospital, Birmingham, the only parts of the windows made to open are the top-hopper windows. (See *ante* pp. 132, 133.)

When a window is allowed for each bed, which is generally the case, the wall-space between the windows should be 8 to 12 inches wider than the bed. In some of the older hospitals, however, an allowance of one window for every two beds is generally considered sufficient, the beds being arranged in pairs between the windows, and separated from each other by a distance of at least 3 feet. The windows should reach from within 2 feet, or 2 feet 6 inches from the floor, to within 1 foot from the ceiling. The space between the end wall and the first window on either side of

the ward should be 4 feet 6 inches, and the space between the adjacent windows 9 feet, the windows themselves being 4 feet 6 inches wide. An end window to a long ward adds greatly to its cheerfulness, and aids materially in the ventilation of the ward. The ordinary sash window made to open at top and bottom, with a fall in or hopper window above, is perhaps preferable to any other kind. To economise heat, plate-glass should be used instead of ordinary glass. To thoroughly ventilate the corners of wards a narrow window should be provided at each corner between the beds and the return walls.

When there is no system of mechanical ventilation and warming, the extraction-flues, when not contiguous with a chimney, should be provided with gas-jets to aid their extractive power. If the fire-places are situated in the centre of the ward, the extraction-flues should be placed alongside the flues and separated from them by iron plates. The inlets to extraction-flues ought to be near the ceiling, except when the *plenum* system of ventilation is adopted, and then they are placed near the floor.

The fire-places best suited for infirmary wards are the ventilating stoves with open grates back and front, and situated in the centre of the ward and with flues passing under the floors and up the opposite walls. But in addition to these, or in place of them, the fresh air might also be heated by hot-water pipes.

The furniture in a ward ought always to be reduced to a minimum, and should never be cumbrous or bulky. Iron bedsteads are to be preferred to wooden ones, and thin horse-hair mattresses, laid on woven wire mattresses, to thick flock or woollen mattresses. All bedsteads should be ranged at a short distance from the walls. Coverlets and blankets should be white or light-coloured, to show dirt, and ought to be frequently aired.

The other points of sanitary importance connected with a ward are its offices, and the materials employed in construction.

Ward-offices are required for facilitating nursing, and for

the direct use of the sick. Thus every ward should have attached to it, at the end nearest the door, a scullery or nurse's room, a room for linen cupboards, etc., and a separation ward if necessary, and at the farther end a water-closet and ablution-room. The nurse's room or scullery should be fitted with a small range for warming drinks, preparing fomentations, etc.; a sink with hot and cold water laid on; and shelves and racks for dishes.

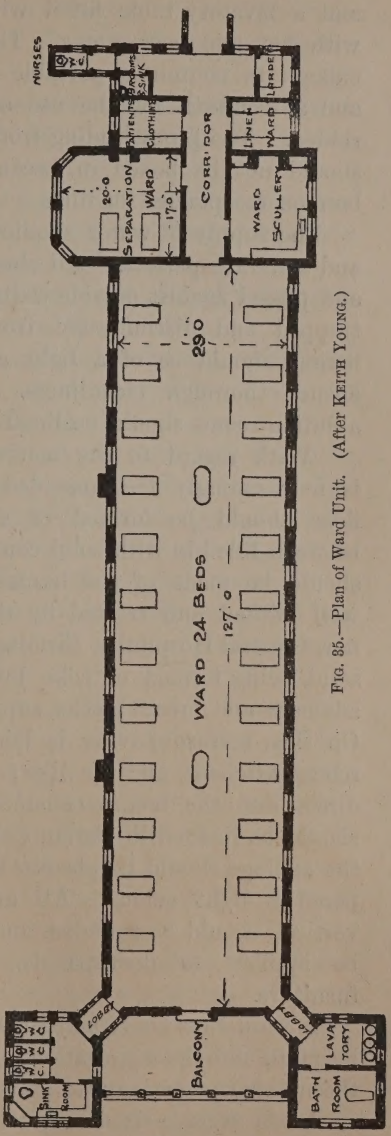


Fig. 85.—Plan of Ward Unit. (After Keith Young.)

The water-closet and ablution-blocks should be situated, one at either farther corner of the ward, and both should be completely cut off, by means of swing-doors and a lobby supplied with cross-ventilation, from the ward. The water-closet apartment ought to contain one closet for every ten beds, or three closets for thirty-two, and should also be supplied with a sink and urinal. The closets should be of the flush-down, or short hopped kind, and be provided with silent-acting syphon flush cisterns, and with hinged seats.

The ablution-room should contain a plunge-bath with hot and cold water laid on, a

shower-bath overhanging the broad end of the plunge-bath, and a lavatory table fitted with basins, and also supplied with hot and cold water. There should likewise be room enough to contain a portable bath on wheels, a hip-bath, and a foot-bath for the use of patients more or less bed-ridden. The pipes leading from the sink and lavatory table should not be boxed in, because the spaces thus enclosed become receptacles for dirt.

The supply of water should be ample, and the drainage and sewerage perfect. All closet-pipes should be ventilated and placed against outside walls, and all other pipes properly trapped and disconnected from the drains. The various fittings should be of a light colour, to show dirt, and thus ensure thorough cleanliness. The walls of closets and ablution-rooms should be lined with glazed tiles.

With regard to the materials of ward construction, it is now strongly recommended that the framework of the floor should be formed of steel joists, with the spaces between filled in with solid concrete, and that the floor itself should be made of the hardest wood, such as oak or teak, well jointed and treated by the paraffin process. In the new General Hospital at Birmingham, the floors are absolutely solid, being formed of coke breeze and cement concrete on adamant and breeze blocks, supported by rolled steel joisting. On this, terrazo paving is laid for all corridors, operating rooms, kitchens, and the like; and teak boarding is nailed direct into the breeze concrete for the wards. The walls should be lined with Parian cement or adamant plaster, and the ceilings should be plastered and whitewashed, or distempered a light colour. All angles, whether horizontal or vertical, should be rounded, and the same principle should be applied to door-panels, window-panes, and ward furniture.

A ward thus constructed and arranged is in itself a small hospital, and the aggregation of ward units will depend on the number of patients to be accommodated.

In an average-sized hospital the administrative buildings occupy considerable space, and may be variously distributed.

All of them, however, must be made entirely subservient to the requirements of the sick, and should not interfere with the ventilation of the wards. Usually the administrative buildings are as follows:—

Kitchen, provision-stores, and stores for bedding and linen. These should be central. The kitchen should be situated on the top of the buildings.

Apartments for house-surgeon, matron, and servants; consulting-room, waiting-room, surgery, drug-store, and operating-room; all of them more or less central.

Laundry, mortuary, post-mortem room, disinfecting-room. These should all be detached from the building.

Nurses should have well-ventilated bedrooms, either in a separate block, or at the top of the central block, with all the necessary appliances for ablution, etc.

The staircases should be broad and easy, and should be cut off from the connecting corridors by swing-doors. The corridors themselves should be as low as possible, well-lighted and ventilated. It is sometimes advantageous to construct all staircases and lifts in the central block.

Generally the administrative buildings take up about half the cubic space of the whole hospital. As very good examples of the pavilion form of hospital on the small scale may be mentioned the Royal Hants County Hospital at Winchester, the Buckinghamshire County Hospital at Aylesbury, and the New Hospital at Swansea. Amongst average-sized hospitals, the Great Northern Hospital at Holloway, designed by Messrs. Keith Young and Hall, and the New General Hospital at Birmingham, designed by Mr. Henwood, may be instanced as illustrating all the most recent improvements in hospital construction.

With regard to the cost of pavilion hospitals, Sir Douglas Galton is of opinion that, with care and attention to economy in the design, a hospital for in-patients only, and built on a favourable site, should not cost more than from £90 to £120 per bed. The Leeds Hospital, which accommodates 350 patients, cost £197 per bed; the Royal Hants Hospital, with 108 beds, and including accommodation for out-

patients, cost £229; and the Swansea Hospital, also including an outside-patient department, cost £142 per bed. Hospitals consisting of circular wards, as at Greenwich and Antwerp, have been advocated by some, but it is doubtful whether they possess any advantages over the pavilion system.

Day-wards, exercising grounds, and flower or winter gardens, are great additions to the sanitary advantages supplied by a well-constructed hospital. In summer, all the patients who are able to move about, and, indeed, most of those who are bedridden, should be allowed to remain during some part of every warm day in the open air. The flat roofs of the corridors, protected by awnings, could be utilised for the bedridden patients of the upper wards, while the corridors themselves might be appropriated by the same class of patients belonging to the lower wards. At the Great Northern Hospital, Holloway, the roofs of the pavilions are flat, so that they can be used as airing grounds, and it is also of advantage to provide verandahs or balconies at each ward level, between the ablution and water-closet blocks, as shown in Fig. 35.

Section II.—Cottage Hospitals

The cottage-hospital system, originated by the late Mr. Napper of Cranleigh, is based on the principles of providing hospital accommodation for the sick poor of rural districts, with as much of the surroundings of home as possible; of permitting equality of privilege to subscribers in recommending patients, the patients themselves paying a certain sum weekly, according to their means; and of allowing any medical man practising in the district the use of the hospital for deserving cases under his care. The model cottage hospital should not have more than twenty beds, and must be under the management of one medical man as director, appointed either permanently or by rotation, the other medical men in the district holding office as honorary medical officers. The annual cost of the establishment is

defrayed chiefly by voluntary contributions and partly by the weekly payments of the patients. These weekly payments, as already stated, are regulated by the means of the patient, and vary from 2s. 6d. when the Union has to help, to 5s. or 8s. when the patient has been earning fair wages, or belongs to a club. All fees allowed by the Union for accidents or operations are paid to the Union Medical Officer, in the same way as if he had attended the patient at his own home. Every subscriber, no matter what the amount of his subscription, should have equal privileges in recommending cases, and will generally be able to state what amount the patient whom he recommends can afford to contribute weekly. Cases of accident and emergency are admitted without order, but otherwise a recommendation from a subscriber must be procured, and this should in all instances be accompanied by a certificate from one of the medical staff, to the effect that the case is one deserving and fit for admission. Only those are admitted who cannot be efficiently treated at their own homes, while cases of infectious or incurable disease are excluded. In some few hospitals, pay patients are admitted where there is sufficient accommodation, and it is rightly urged by Sir Henry Burdett in his excellent work on *Cottage Hospitals* that this system should be extended to all hospitals.

Experience has proved that in rural districts a cottage hospital of six beds will suffice for a population of 6000. The initial outlay will of course depend on whether a cottage which has already been built can be procured, and, if so, what alterations will be necessary to convert it into a hospital. If the hospital has to be built, the amount required may be estimated at £600, or about £100 per bed. In converting a cottage which has already been occupied into a hospital, the walls should be thoroughly cleaned, scraped, and afterwards replastered and washed with caustic lime. Attention must also be paid to the sanitary surroundings of the building.

The cost of furnishing a cottage hospital for six beds will amount to about £100, and the necessary surgical

instruments to about £50. The maintenance per patient weekly would cost from 10s. to 15s., so that the hospital, when once started and properly furnished, will require for its support an annual income of at least £150, about £25 or £30 of which will be subscribed by patients.

Although the architectural arrangements may admit of many variations, the plan best suited for a cottage hospital of six beds should provide for a nurse's room, a three-bedded male ward, a two-bedded female ward, a single-bedded ward, which can be used as an operation room, a kitchen, which may also be used as a day-ward, a scullery, and a small mortuary. All the rooms should, if possible, be on the ground-floor, so that good roof ventilation and ample cubic space may be secured. Part of the roof should overhang, so as to form a sort of verandah for the use of patients. It need scarcely be added that a tasteful arrangement of flowers and shrubs in the space immediately surrounding the hospital will add greatly to its cheerfulness.

As regards nursing, cooking, and management, much will depend on the size of the hospital, but efforts should always be made to secure the services of a trained nurse.

The drainage and sanitary fittings should be on the lines laid down in Chapter X.; but where no water is laid on, the pail or dry-earth system is to be preferred. (See *Cottage Hospitals*, by Burdett.)

Section III.—Isolation Hospitals

By the 131st clause of the Public Health Act, 1875, power is given to the sanitary authorities of any town or district to provide, for the use of the inhabitants, "hospitals or temporary places for the reception of the sick"; and when such provision has been made, any Justice may order the removal to the hospital of any person suffering from a dangerous infectious disease who is without proper lodging, or lodged in a room containing more than one family, or is on board ship. Judging from my own experience, however, and that of other health officers, it is very seldom that a

magistrate's order is required for the removal of a patient, inasmuch as patients and their friends are, as a rule, only too glad to avail themselves of the advantages of a hospital of the kind, when proper isolation and adequate nursing cannot be procured at their own homes.

In a memorandum re-issued by the Medical Officer of the Local Government Board in 1895, it is recommended, as a condition of the first importance, that the accommodation for isolating cases of infectious disease shall be ready beforehand; and further, that it shall be sufficient for the treatment of different infectious diseases separately. The amount of accommodation required will of course vary for different places. As regards villages, for example, it is recommended that "large villages and groups of adjacent villages will commonly require the same sort of provision as towns. Where good roads and proper arrangements for the conveyance of the sick have been provided, the best arrangement for village populations is by a small building accessible from several villages; otherwise the requisite accommodation for (say) four cases of infectious disease in a village may be got in a suitable four-room or six-room cottage at the disposal of the Sanitary Authority; or by arrangement made beforehand with some trustworthy cottage-holders, not having children, that they should receive and nurse, on occasion, patients requiring such accommodation."

"*In towns,* hospital accommodation for infectious diseases is wanted more constantly, as well as in larger amount than in villages; and in towns there is greater probability that room will be wanted at the same time for two or more infectious diseases which have to be treated separately. The permanent provision to be made in a town should consist of not less than four rooms in two separate pairs; each pair to receive the sufferers from one infectious disease, men and women of course separately. The number of cases for which permanent provision should be made must depend upon various considerations, among which the size and the growth of the town, the lodgment and habits of its population, and the traffic of the town with other places, are the

most important. There is no fixed standard, therefore, by which the standing hospital requirements proper for a town can be measured. Furthermore, it is to be remembered that occasions will arise (as where infection is brought into several parts of a town at one time) when isolation provision, in excess of that commonly sufficient for the town, will become needful."

"For a town, the hospital provision ought to consist of wards in one or more permanent buildings, with space enough for the erection of other wards, temporary or permanent. Considerations of ultimate economy make it wise to have permanent buildings sufficient for somewhat more than the average necessities of the place, so that recourse to temporary extensions may less often be necessary. And in any case it is well to make the administrative offices somewhat in excess of the wants of the permanent wards; because thus, at little additional first cost, they will be ready to serve, when occasion comes, for the wants of temporary extensions."

Practically, however, it is found that sanitary authorities are generally so averse to providing any accommodation of the kind, unless under the stern pressure of an epidemic, that in rural districts especially, the health officer may consider himself fortunate if he succeeds in obtaining a hospital sufficiently central to meet the requirements of a whole union, or at least the most populous parts of it. With a good ambulance, provided with rubber tyres, and well warmed by foot-warmers in cold weather, patients, if fit to be moved at all, can be moved a distance of ten to twelve miles without any risk.

The question here arises, and it is a somewhat difficult one to answer, What should be the ratio of beds to the population for whose wants the hospital is to be provided? The late Sir George Buchanan laid down the ratio of one bed to every 1000 inhabitants, and no doubt, taking this as an average estimate, it may be considered as fairly accurate. But much will depend upon the special circumstances of the district and population. For example, a poor

crowded district will require a larger amount of accommodation than a district not crowded, and whose inhabitants are on the whole well-off. In the latter case, the ratio of one bed to every 1500 or 2000 inhabitants, with means for temporary extension, if it should be required, might be considered sufficient.

It need hardly be said that the greatest difficulty is frequently experienced in obtaining a site. Vested interests at once take alarm because the popular prejudice against living in the vicinity of such hospitals is so great that property will, for the time being, depreciate in value. The site, therefore, which may be ultimately fixed upon may not be free from objection, but it should always be such that no sanitary objection can be raised against it. If the soil is stiff and clayey, special care ought to be taken, by means of drainage, a free use of concrete or asphalt, and abundant ventilation, to secure perfect dryness of the building. The building itself should be sufficiently central as regards the distribution of the population of the district, sufficiently accessible from all parts of the district, and, if possible, well isolated. In rural or suburban districts, there ought to be no difficulty in obtaining an abundant supply of good water, nor any difficulty in getting rid of the excremental matters and slops.

The question of cost of site will of course vary immensely according to the circumstances of the district, while the amount of space required will also vary considerably. But, speaking roughly, no site, to afford sufficient isolation, should be less than one acre in extent, and a hospital, say of thirty beds, would require about three acres. Then, too, the site should be surrounded by a suitable fence to cut off all communication except through the lodge entrance, and such fence, as stipulated in the Local Government Board memorandum, should be a wall about 6 feet 6 inches high. It is also insisted on by the Local Government Board that all the buildings should be at a distance of at least 40 feet from the nearest boundary or fence.

The difficulties in respect to sites for the isolation of

cases of small-pox, as well as of other cases of infectious disease, are greatly increased by the conditions laid down by the Local Government, namely, that local authorities should not contemplate the erection of a small-pox hospital—

"1. On any site where it would have within a quarter of a mile of it as a centre either a hospital, whether for infectious diseases or not, or a workhouse, or any similar establishment, or a population of 150-200 persons."

"2. On any site where it would have within half a mile of it as a centre a population of 500-600, whether in one or more institutions or dwellings."

These conditions are imposed in consequence of the report of the Royal Commission on Small-pox and Fever Hospitals, issued in 1882, which made it but too clear that small-pox hospitals have again and again served to disseminate that disease to neighbouring communities "in spite of precautions almost in excess of any that could have been anticipated." Although many are prepared to contend that the aerial convection of small-pox can only operate within very limited distances, and that the spread of the disease around such hospitals can be explained by the passing of ambulances through crowded thoroughfares, and the difficulties in securing complete precautionary measures in the management of a small-pox hospital or block when it adjoins other blocks of an isolation hospital, it must be conceded that there is always more or less risk if a block used for the reception of small-pox cases is not completely isolated from other blocks in respect to catering, nursing, disinfection and washing of clothing, and a separate ambulance. But the Local Government Board are so impressed with the dangers of aerial convection to long and undefined distances that no loans can be granted for the extension of an isolation hospital, or the erection of any new hospital, unless an undertaking is entered into that no building or block within the above prescribed limits shall be used for the reception of cases of small-pox. This practically means that local authorities, in order to properly safeguard the sanitary defences of their districts, must procure two hospital sites,

and apart from the question of extra cost, they often find themselves powerless to procure dual sites, and when small-pox does break out, do the best they can with existing means of isolation.

Although County Councils were empowered by the Isolation Hospitals Act, 1893, to create hospital districts, on representations being made to them, by combining sanitary districts for that purpose, and also to contribute out of the county rate "a capital or annual sum towards the structural and establishment expenses of an isolation hospital," it must be confessed that, throughout the country generally, very little has yet been achieved in providing adequate hospital accommodation for small urban and rural populations, partly because the councils find themselves practically powerless to open their purse-strings in this direction, owing to strenuous opposition from among their own numbers, and also on account of the difficulties of obtaining suitable dual sites under the conditions imposed by the Local Government Board. For powers in respect to isolation hospitals provision see Chapter XIX.

The very valuable report prepared by Sir Richard Thorne for the Local Government Board in 1882, and reissued by the Board in 1894, presents much useful and varied information on points of administration and construction of isolation hospitals, derived from experience of them in various parts of England and Wales, and the following table gives important particulars with regard to the best permanent hospitals which he visited :—

District.	Estimated Population.	Number of Beds.	Present Bed-rate per 1000 of Population.	Floor-space per Bed, in Square Feet.	Ward capacity per Bed, in Cubic Feet.	Cost of Hospital, excluding Cost of Site.	Cost per Bed, exclusive Cost of Site.
						£	£
Berkhampstead, rural . .	11,000	8	0·7	144	2000	2,162	270
Cheltenham, urban . .	44,000	32	0·7	Varies; mean is 144	Varies; mean is 2300	11,121	347
Darlington, urban . .	35,000	44	1·3	144 to 175	2000	10,123	225
Folkstone, urban	18,700	14	0·7	140	2000	2,800	200
Lewes, combined districts .	11,200	12	1·1	144	2000	1,975	164
Middlesborough, urban . .	56,000	32	0·6	122 to 180	1620 to 2100	6,829	213
Sheffield, urban	285,000	64	0·2	138	1810	19,785	309
Solihull, rural .	20,000	12	0·6	144 to 156	2000 to 2184	2,892	241
Tonbridge, urban . .	10,000	12	1·2	140	2000	1,394	116
Warrington, urban . .	42,000	28	0·7	144 to 175	2058 to 2529	6,555	234
Weymouth, port	?	26	?	144 to 169	2014 to 2028	5,135	192

The new Joint Hospital recently built for Warwick, Leamington, Kenilworth, and the Warwick rural district, and designed by Mr. Keith Young in accordance with the plans of the Local Government Board, cost £400 per bed.

Permanent hospitals should be built of brick or stone, and not of wood or corrugated iron, because, apart from other reasons, it was found in the course of Dr. Thorne's inquiry that it was very difficult to maintain in the latter class of buildings a sufficiently warm temperature in cold weather. They should be built on the pavilion system, and consist of an administrative block; at least four wards, in two separate pairs, in which patients of both sexes, suffering

from two different infectious fevers, can be treated simultaneously; and certain outbuildings, such as mortuary, laundry, disinfecting chamber, etc.

The administrative block is usually built in excess of the requirements of the permanent pavilions, so as to be commodious enough for any future extensions, should they become necessary; and where it is desirable to economise space, it should be a two-storied building. It should not communicate with the pavilions; and, indeed, the Local Government Board recommend that all covered ways should be dispensed with between the different blocks.

The pavilions themselves are generally one-storied buildings, but where a site is necessarily limited Dr. Thorne saw no reason to object to two-storied pavilions, provided of course that only patients suffering from one kind of infectious disease are treated in the same pavilion—the patients of one sex on one floor, and the patients of the other sex on the other floor. The distance between the several pavilions and between them and the administrative block should be equal to one and a half times their height, and when the buildings are of unequal height, it should at least be equal to the full height of the higher of the adjacent buildings. It is advisable, too, that arrangements should be made for the reception of better-class patients into a separate block of small wards; and there is no doubt that such an addition to most isolation hospitals would be a great boon to paying patients, besides affording means for isolating noisy or delirious patients and doubtful cases.

Plans illustrating the sanitary requirements of small hospitals for infectious disease are arranged on three sheets accompanying the memorandum of the Local Government Board. On the first sheet is the plan of a small building to hold two patients of each sex. On the second sheet, a plan and a section of a rather larger hospital building are shown, providing for six patients, with separation of sex, and also of one infectious disease from another. The third sheet shows (Fig. 36) a small pavilion adapted to receive six male and six female patients suffering under one kind of infectious

disease. On the same sheet is placed a plan (Fig. 37) of a ward block for ten patients, of similar design to plan on second sheet, and a convenient disposition of buildings upon site is also indicated.

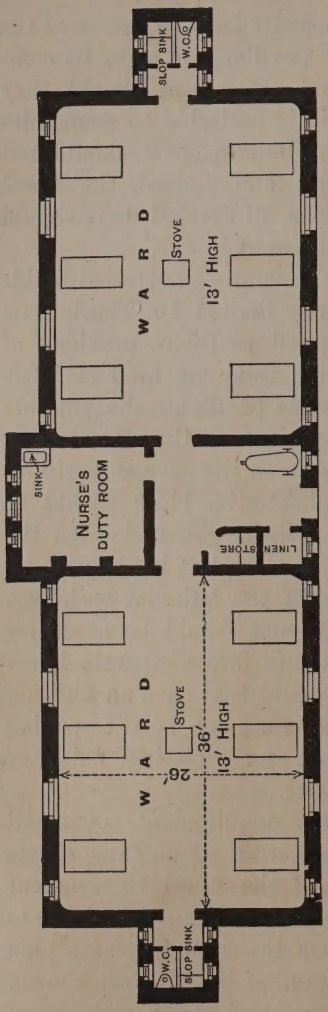


Fig. 36.

The cubic space per bed, according to the memorandum of the Local Government Board, should be at least 2000 feet, the minimum floor space per bed 144 square feet, and the linear wall space 12 feet per bed. The height of the wards should be 13 feet, and no additional height should be taken into account in reckoning the cubic space. The floors should be closely jointed, the walls either covered with Parian cement, or made smooth and lime-washed and coloured, and flat ceilings without cornices should be preferred to pitched roofs. The windows should be double-sashed, combined with fall-in or hopper windows above, and be evenly distributed in the opposite walls, so as to ensure efficient cross-ventilation. The best arrangement is found to be that which provides for one window between each bed, and one near the angles of the ward beyond each end bed. They should reach from about 3 feet above the floor level to within 6 inches of the ceiling or wall-plate, and the amount

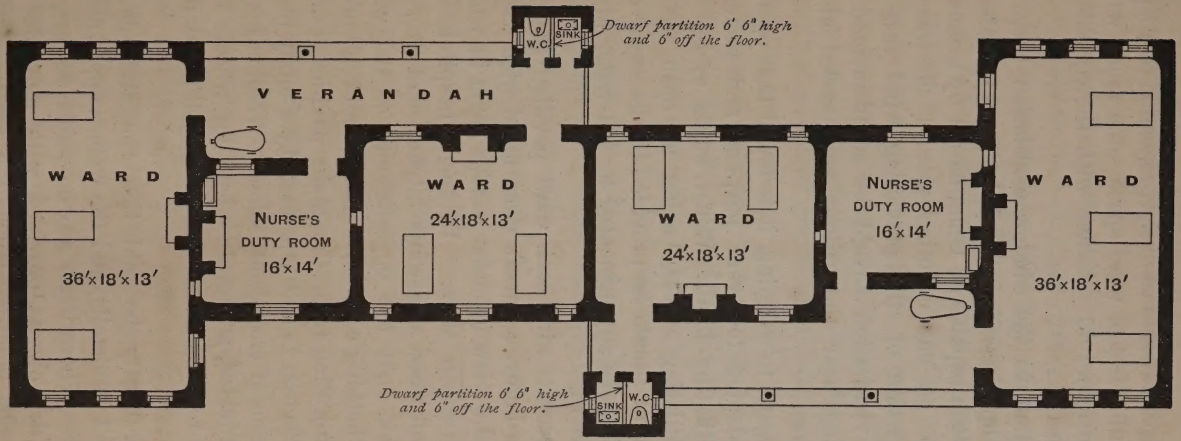

Dwarf partition 6' 6" high
and 6" off the floor.
W.C
SINK
VERANDAH
WARD
36'x18'x13'
NURSE'S
DUTY ROOM
16'x14'
WARD
24'x18'x13'
WARD
24'x18'x13'
NURSE'S
DUTY ROOM
16'x14'
WARD
36'x18'x13'
Dwarf partition 6' 6" high
and 6" off the floor.
SINK
W.C

FIG. 37.

of window space should be in the proportion of 1 square foot to about 70 cubic feet of ward space—too much window space having been found to interfere with the equable warmth of the contained air.

In addition to the window ventilation, there should be ventilating openings under each bed, and just above the floor level, and each capable of being closed by means of a small sliding door on one or other side of the ward, according as the direction of the prevailing wind may determine. The ward ventilation should be supplemented by special flues opening near the ceiling, and carried alongside the chimney flues.

With regard to warming, it is found that open fire-places are best adapted for ward purposes, and preferably those of the ventilating kind. When wards exceed 30 feet in length, ventilating stoves, having an open fire-place both back and front, should be provided in the centre of the ward, and these may be supplemented by hot-water pipes running round the ward.

In connection with each ward pavilion there should be an entrance lobby, a nurse's room fitted with fixed windows to command a view of either ward, a room in which to store food, and a linen store. In small hospitals the nurse's room is often fitted as a ward kitchen, and provided with a scullery sink. At the opposite end of the ward, closets, sinks, and bathing accommodation should be provided in a building projecting from the main pavilion, as already described in Section I., and separated by a lobby provided with efficient means of cross-ventilation. When no separate bath-room is provided, a movable bath on wheels is found to answer the requirements of small hospitals, as indicated in Fig. 37.

It need hardly be said that the drainage should be perfect in all its details, and the water-supply abundant and wholesome. Where there are no public sewers, the closets should be dry closets, provided with movable receptacles, which can be removed through a small doorway in the outside wall, and the best way of treating the slops is

by sub-irrigation from a septic tank or cess-pool. (See Chapter XI.)

The furniture of the wards should be simple and neat; and, for obvious reasons, all bed-curtains, carpeting, or matting should be prohibited. The best kind of bedsteads are iron bedsteads, provided with wire woven mattresses, and thin horse-hair beds, which can be easily disinfected in a disinfecting chamber.

The outbuildings should consist of a porter's lodge, if the hospital is of considerable size, a mortuary, a laundry, an ambulance shed, and a disinfecting chamber, and, if necessary, a post-mortem room—all of which should be built at a safe distance from the pavilions.

Among the newer hospitals built on the best plans may be mentioned the Warwick Joint Hospital with 22 beds, the Newcastle Hospital with 105 beds, the Nottingham Hospital with 140 beds, the Hull Sanatorium with 150 beds, and the more recent Metropolitan Fever Hospitals.

The management of a small isolation hospital would be very much like that already described as suitable for a cottage hospital. A medical officer should be appointed who would have full powers as superintendent, but any patient should have the option of being placed under the care of his own medical attendant should he desire it, provided he pays for the cost of attendance. No obstacles ought to be thrown in the way of admitting patients, and no payment should be insisted on except in special cases or where private wards are provided. A skilled nurse can always be obtained on the shortest notice from any of the excellent nursing institutions advertised in the medical papers. At times when the hospital is not occupied, the building and bedding should be kept clean and well aired. Strict rules of management should be drawn up.

An indispensable adjunct to a hospital is a well-constructed ambulance. For small or averaged-sized districts, this should resemble an ordinary brougham with a door opening behind to receive a stretcher, in addition to side doors, and with sufficient space under the boot or driver's seat for

the foot-end of the stretcher. The wheels should have rubber or pneumatic tyres, while the stretcher should be made of woven wire and the handles jointed, so that when the stretcher is placed in the ambulance the handles will not encumber any of the space. In addition to the stretcher, there should be a hinged seat near the door for the attendant, and one or two hot-water cans to secure sufficient warmth in cold weather and during a long drive. After being used, the ambulance should be thoroughly disinfected.

When an isolation hospital, or temporary extension of an existing hospital, is required at very short notice, it may be run up of wood or of corrugated iron and wood, such as the huts designed by Humphreys and Co. of Knightsbridge, London. Double-canvas tents pitched on wooden floors have also been utilised to meet an emergency at Grantham, Newark, Wednesbury, and other localities, and with a large amount of success. If a number of tents are used, they are most conveniently warmed by hot-water pipes; but isolated tents, such as those supplied by Edgington and Co., London Bridge, and other manufacturers, can be warmed by stoves. Patent portable hospitals on the Doecker system are also found to answer very well, but none of these substitutes should be regarded as meeting the permanent requirements of any locality.

At seaport towns it is proposed to use hospital-ships of the "Dreadnought" type, but for an emergency any old vessel with a sound hull, and large enough would suffice. Wooden huts erected on the upper deck would supply the ward accommodation, while the body of the vessel could be utilised for the administrative department. Such hospital-ships have been used on the Thames for the reception of small-pox cases, but should only be regarded as adjuncts, and not as substitutes, for permanent hospitals on shore. At several port-sanitary districts, however, as at Newcastle-on-Tyne, admirably arranged floating hospitals have been provided for the reception of cases of infectious disease from incoming vessels.

CHAPTER XV

INFECTIOUS AND PARASITIC DISEASES

Section I.—Bacteriology in Relation to Infection, Prophylaxis, Anti-rabic Vaccination, and Serum Therapy

The rapid strides which bacteriology has made during recent years has not only threatened to revolutionise the older theories concerning the causation and mode of propagation of infectious diseases, but has rendered any attempt at scientific classification extremely difficult. The term *zymotic*, however, is still so far in harmony with modern views, that it is retained by the Registrar-General to designate those diseases which in their course present more or less resemblance to the process of fermentation, and on account of their communicability or infectious nature, are of the highest hygienic concern. The term *specific*, again, though it embraces a large proportion of these diseases, is more limited in its application, because it assumes that the origin, *de novo*, of a contagium is as impossible as the spontaneous generation of plants or animals.

Both terms are based on "the germ theory of disease," which, in the light of recent researches, may now be said to have reached the stage of positive demonstration. Broadly stated, this theory affirms that certain diseases are invariably associated with the growth and multiplication in the system of characteristic specific micro-organisms, and that these micro-organisms are the actual contagia or causes of the disease. In fact, the germ theory has become merged in

the more precise doctrine of the microbial or micro-parasitic origin of the so-called specific diseases.

In respect to a few diseases the proof is regarded as complete, inasmuch as the conditions, first categorically stated by Koch, are capable of experimental demonstration. These are—

(1) That the specific micro-organism must be found in the blood or tissues of the man or animal suffering or dead from the disease.

(2) That this micro-organism can be isolated and cultivated in artificial media for any required number of successive generations.

(3) That a pure cultivation thus obtained must, when inoculated into a susceptible animal, reproduce the same disease.

(4) That in the blood or tissues of the inoculated animal the specific micro-organism must again be found, and be distributed as in animals infected in the ordinary way.

As the third condition is, as a rule, inapplicable to human beings, the complete proof is practically limited to diseases which attack the lower animals, but the list of such diseases, which are regarded as microbial in their origin and propagation, is now very considerable, and they include fowl-cholera, swine-fever, foot-and-mouth disease, pyæmia, and various septic diseases. The chain of evidence is also regarded as practically complete in respect to certain diseases which are common to man and the lower animals—namely, anthrax, tuberculosis, erysipelas, glanders, tetanus, and, possibly, diphtheria, and scarlatina. In respect to several other diseases, however, all that can be asserted so far is this, that though a characteristic micro-organism is constantly found in the blood or tissues of persons suffering from these diseases, its direct causative relation can only be inferred. Then, again, there are other diseases which prevail in devastating epidemics, such as measles, whooping-cough, small-pox, typhus fever, and influenza, in which no characteristic microbe has been isolated with certainty, and it is only by analogy that their microbial origin is assumed.

So far, therefore, the microbial origin of many of the most important of the infectious diseases is not yet capable of positive demonstration, and indeed there are many who maintain that even in respect to those diseases common to man and animals, in which the proof is regarded as more or less complete, the symptoms and pathological manifestations of the disease which is induced by the inoculation of cultivated virus exhibit wide divergencies from those observed in the natural disease, although the presence of the so-called specific microbe cannot be disputed. Equally conflicting are the views which have been advanced concerning the precise relation which exists between the infective material, whatever its nature, and the phenomena of disease which it induces. Some hold that the enormous multiplication of microbes or pathogenic bacteria in the system act injuriously, mainly by depriving the red corpuscles of their oxygen, or by clogging the minute capillaries by their excessive multiplication; while others maintain that they secrete a ferment or *enzyme*, which in its turn diffuses and acts as a poison. These poisons, or products of the metabolism of the bacteria, are variously known as *ptomaines*, *toxalbumoses*, or *toxins*, and it is now generally held that all pathogenic organisms produce the specific diseases with which they are associated by means of these toxins which they elaborate. Some of them, and notably the bacilli of diphtheria, do not invade the circulatory system or internal organs; they only multiply at the seat of infection or inoculation, and there elaborate the toxins which are absorbed into the system. Others again, such as those of relapsing fever in man, and anthrax in animals, rapidly invade the whole system, and multiply enormously in the blood, as well as in the internal organs.

With regard to the bacteria themselves, it may be said briefly that they all belong to the class of fungi known as *schizomycetes*, because they multiply by a process of fission, or by the formation of spores. Each single micro-organism consists of a small speck of protoplasm or vegetable albumen, and is classified according to form,—spherical or rod-shaped. The spherical bacteria are termed *micrococci*, and rarely

exceed $\frac{1}{20000}$ of an inch in diameter, and they are further differentiated according to the disposition of their grouping —into *diplococci*, when in twos; *tetracocci*, when in fours; *sarcinacocci*, when in eights; and *streptococci*, when grouped in chains or linear series. When they occur in clusters or botryoidal groups, they are designated *staphylococci*. The rod-shaped bacteria, on the other hand, are termed *bacilli*, which are of the most varied lengths—some of them elongating into filaments which may be straight or spirally twisted, or sometimes branched. They all multiply, however, by fission or sporulation, and their resistance to light, heat, cold, desiccation, or chemical agents, especially when in the spore stage, is often very great, though all these agencies exert an attenuating or lethal influence according to their intensity. Thus, Professor Marshall Ward found that the extremely resistant spores of anthrax could be destroyed by exposure to sunlight in from two to six hours, while Duclaux and others proved by experiment that, even in diffused light, various pure cultures of bacteria become attenuated in their pathogenic power.

Generally speaking, pathogenic organisms require a temperature of 35° to 40° C. (95° to 104° F.), for their growth and development, while the temperature required for their destruction is much higher with dry heat than when moist heat is employed. Thus, the spores of the anthrax bacillus have been found to resist a temperature of 140° C. (284° F.), but with moist heat the spores of most of the known pathogenic organisms are quickly killed by a short exposure to 100° C. (212° F.). With regard to the influence of cold, it has been ascertained that several organisms, such as the typhoid bacillus, will survive freezing for lengthened periods; while in respect to the influence of desiccation, Koch and Kitasato found that a broth culture of the cholera bacillus, when dried in the form of a very thin film, was incapable of development after three hours' drying. Chemical agents are bactericidal on account of their destructive action on protoplasm, but in varying degrees;—some of the so-called disinfectants possessing only a retarding or attenuating influence.

Although all the known pathogenic organisms are necessarily *parasitic*, in the sense of drawing their nourishment from some living body or "host," they are also *saprophytic*, in the sense of being capable of abstracting their nourishment from dead organic matter, as in culture media under certain conditions of temperature. As has been shown in Chapter XII., several of the so-called specific bacilli, and especially those of diphtheria and enteric fever, thrive readily in filth-polluted soil as a culture medium, and it does not follow therefore that particular specific diseases must descend in a continuous series from antecedent cases. Indeed, the whole trend of the influence of environment, or of "soil and circumstance," leads to the conclusion that, in respect to "filth diseases" especially, the pathogenic properties of their characteristic organisms may be acquired in the transition from a life, which has hitherto been solely saprophytic, to a life which becomes parasitic, and therefore specific. Though the organisms themselves are not generated *de novo*, their progenitors, so to speak, may never have had their habitat in man or animals; but so soon as they acquire an intensity, by means of their environment, to produce disease, and invade man or animals through the media of air, water, food, or by contact or inoculation, the disease has practically a new beginning in all such invasions or attacks. Granting, then, that there is "no life without antecedent life," the *de novo* origin of some of these diseases can be readily explained by this doctrine of microbial evolution. Sporadic cases of specific disease, which cannot be traced to previously existing cases, can thus be accounted for, as well as the often far-reaching spread of infection from such cases. On the other hand, it becomes quite clear that organisms which are, or have become, parasitic, and therefore specific, are constantly exposed to degenerating or attenuating influences after leaving a living host, so that, without entirely losing their pathogenic power, they can only act with modified virulence on a fresh invasion or attack. Indeed, it becomes an open question whether the influence of the host, or the media in which the organisms grow, or are conveyed, may

not originate new varieties of disease as well as modifications of type. This doctrine of microbial evolution, and microbial degeneration or attenuation, is especially applicable to the sporadic and often ill-defined cases, as well as the limited outbreaks, of enteric fever, diphtheria, autumnal diarrhœa, and epidemic pneumonia in man; and of anthrax, pig-typhoid, and pleuro-pneumonia in animals, which are constantly cropping up in rural districts, and can therefore be investigated under much more precise limitations than in towns.

What is called the *period of incubation* of an infectious disease, or the time which intervenes between actual infection and the appearance of the first characteristic symptoms, is assumed to represent the period of development and multiplication of the specific organisms, or their toxins, in the system, while their full development represents the type and course of the disease; recovery, their decline and ultimate destruction; and death, the result of their toxicity or lesions which they produce. But all this does very little to explain the changes which take place in the body during the period of incubation, beyond the assumption that the specific organism with its toxin is multiplying in some part of the system. It is, however, of the utmost hygienic importance to know that for each different infectious disease the period of incubation is tolerably constant, though within certain limits there is often considerable variation in individual cases of the same disease. Mostly all of these diseases run a comparatively short and prescribed course, ending either in recovery or death. A few of them, like chicken-pox, or German measles, present comparatively mild symptoms; while others, like small-pox, diphtheria, or scarlatina, are liable to vary in intensity; but, generally speaking, the mildness or severity of type applies to the great majority of cases in any given outbreak.

Another field of problematical inquiry which has led to much disputation in respect to infectious diseases is the degree of liability or *susceptibility* to attack, and the *immunity* against attack, observable in individual cases. Hereditary

tendency, age, sex, race, and condition of bodily health operate powerfully as so-called predisposing and subjective influences; while season and insanitary conditions always play a most important part, and the latter sometimes the sole important part, in the severity of attacks. No doubt, too, much depends upon the dosage or intensity of the virus, but all this fails to explain the precise *rationale* of the numberless variations observable in the type or course of a disease during its incidence or prevalence. The theory of *micro-strife*, as it is called, merely assumes that, so soon as a colony of pathogenic micro-organisms obtain an entrance into the body, a war commences between them and the leucocytes or white corpuscles of the blood. These leucocytes or *phagocytes*, according to the observations of Metchnicoff, may actually absorb and so destroy the microbes, or they may be destroyed by the bactericidal properties of the blood serum, as shown by Nuttal, Behring, Buchner, Hankin, and others. In either case, if the micro-organisms are killed, no disturbance of health is produced, but if not destroyed, they multiply enormously either at the seat of infection or inoculation, or in the fluids and organs of the body, and, as already stated, secrete toxins which, after a certain time, corresponding to the incubation period, give rise to the phenomena observable in febrile or systemic disturbance.

Metchnicoff's theory of *phagocytosis*, and the theory of the defensive or bactericidal properties of blood serum, have both been advanced to explain what is understood by personal insusceptibility or immunity from infectious disease. Such immunity may be either natural or acquired. The immunity conferred by a first attack of a particular disease, for example, often protects against a second attack of the same disease. In some diseases, such as diphtheria, such protection is only limited and of short duration; while in others, such as small-pox, it practically lasts for a lifetime. In other maladies, again, such as scarlatina, whooping-cough, and measles, increasing age in itself confers varying degrees of immunity. Further, it is a matter of everyday experience that persons living under insanitary conditions become

more or less insusceptible to manifestations of disease which frequently declare themselves in those newly exposed to such conditions. This is often notoriously exemplified in respect to fresh tenants or visitors taking up their residence in houses whose sanitation is faulty. Residents in insanitary houses, as well as in countries where certain endemic diseases prevail, become, as it were, acclimatised to the inimical influences surrounding them, and their immunity would appear to be analogous to that believed to be conferred by protective inoculation by the "minimal" method.

Various theories have been advanced to explain the immunity acquired from a previous attack of an infectious disease, such as (1) the *exhaustion of pabulum* theory, which assumes the removal of some substance from the blood or tissues which is necessary for the growth of the specific organisms, thereby rendering further attack impossible; (2) the *antidote* theory, which infers that during a first attack there is developed in the system some product by the micro-organisms which becomes inhibitory or protective; and (3) the *acclimatisation* theory, which in its turn assumes that, in some way or other, the fluids and tissues of the body are so modified by a first attack as to be able to resist future invasions. But leaving aside these theories, which after all serve to explain very little, the practical outcome of acquired or conferred immunity is simply this—that in some way or other the fluids and tissues of the body become imbued with a power to destroy the invading bacteria or inhibit their growth, and to resist the effects of their toxins; while the process of recovery really represents the development of this power.

What are called protective or preventive inoculations have been effected in various ways,—(1) by using cultures of specific micro-organisms attenuated by continued exposure of successive generations to a high temperature, but not sufficient to destroy them altogether; (2) by cultures prepared in the presence of inhibitory reagents, such as very dilute solutions of antiseptics; and (3) by inoculating with a specific virus which has been attenuated by transmission

through animals of different species. Protective inoculations have also been made with the toxins produced by the growth of pathogenic bacteria in suitable nutrient media. Thus, it is maintained by Behring, Kitasato, Hankin, and others, that they have succeeded in rendering animals immune by injecting subcutaneously repeated and increasing doses of the toxins produced by the diphtheria bacillus, the tetanus bacillus, and the streptococcus pyogenes, when cultivated in suitable media. These toxins are carefully filtered through a porcelain filter, in order to free them from the bacilli, and are then injected into a large animal, such as a horse, in graduated doses, so that the health of the animal may not be impaired. After a protracted period, generally of several months, when immunisation is supposed to be complete, the animal is bled from time to time, and the serum separated under proper antiseptic precautions and stored for use. This serum, it is contended, possesses defensive properties against the toxin of the particular disease, and possesses the power not only of conferring immunity from that disease when injected into the human body, but also the power of arresting the disease if injected shortly after the onset of an attack. Diphtheria antitoxin serum is prepared and used in this way; and though there are many who still maintain that its inhibitory or curative power in the treatment of the disease has not been fully established, it must be conceded that the weight of evidence is so far in its favour. Serum-therapy has also been utilised in the treatment of other diseases, such as tetanus, puerperal fever, and septicæmia, but the evidence of success in respect to these is much more restricted than is the antitoxin treatment of diphtheria.

With regard to protective inoculations with cultures of specific micro-organisms, Haffkine has inoculated large numbers of people in India with cultures of the comma bacilli to render them immune against Asiatic cholera, and similar inoculations have been carried out to protect against plague. On the same lines, and more particularly in connection with the recent severe outbreak of enteric fever at Maidstone, protective inoculations against the disease were

tried with apparent success—so far as warranted by such a limited trial—amongst the nurses and attendants at the Warming Asylum by Professor Wright and Surgeon-Major Semple. Mention, too, should be made in passing of the serum-diagnosis, more especially of enteric fever and what is known as Malta fever. It has been shown by Durham and Widal that when the characteristic micro-organisms are brought in contact with the blood serum of an animal in which the disease has been induced, or of a patient suffering from the disease, the bacteria become agglutinated, lose their mobility, and sink to the bottom of the sedimentation tube in which the serum and culture are mixed, while the culture fluid becomes clarified and the bacteria are devitalised. Indeed, there are some who believe that, with the aid of serum-diagnosis and serum-therapy, it will be possible to discover among recruits all who are susceptible to enteric fever, and render them immune against attack when they are sent out to India or other countries where the disease is endemic.

But admitting to the full the benefits which have accrued from bacteriological research in respect to the etiology and control of infectious diseases, it must be confessed that the vast possibilities of cure as well as protection which were at one time entertained, and eagerly hoped for, still await realisation. And to the unbiassed mind this need not be matter for surprise, when in such a wide field of research and experimentation the possibilities of error are so intricate and varied, that reliable inductions or logical conclusions are rendered extremely difficult. For, in the first place, the air-passages and whole intestinal tract of man and animals are crowded with non-pathogenic organisms, to say nothing of those which teem in the soil, water, and articles of food. These so closely resemble pathogenic bacteria, and many of the latter so closely resemble each other, that their microscopic characters are scarcely in any case sufficiently differentiated to permit of their identification. Indeed, it is generally admitted that identification can only be rendered possible by the *ensemble* of their cul-

tural characters in different media, and by the results of the toxins which they produce in experimental inoculation upon animals. In the second place, as has already been pointed out, it must be conceded that, even in respect to those specific diseases which are common to man and animals, the symptoms and pathological manifestations of the disease, when induced by the inoculation of a cultivated virus, exhibit wide divergencies from those observed in the natural disease, although the presence of the so-called specific microbe cannot be disputed. Then, again, the *rationale* and warranty, so to speak, of all these protective antitoxin inoculations are based on the protection afforded by vaccination against small-pox, and on the protection afforded by a previous attack of an infective disease against a second attack of the same disease. But to those who believe in Jenner's doctrine, that vaccinia is only a modified form of small-pox, and that the pustule on the cow or calf, or on the human arm, is not only the visible manifestation of the disease and its most characteristic symptom, but that it contains the naturally developed virus, there appears no real or legitimate analogy between protective vaccination against small-pox and the protection claimed for inoculation with virus attenuated either by transmission through animals or in culture media. If transmitted through animals, such animals should present the characteristic feature of the special disease in distinctive measure, and the inoculation should be direct from living animal to animal, and from infected animal direct to man, without manipulation of the virus beyond the means required for its storage or conveyance. But with the sole exception of small-pox, no protective inoculation has been attempted in respect to any other disease, so far as man is concerned under these conditions, nor does it seem possible that any such attempt can ever meet with acceptance, no matter what success may attend experiments on animals.

With regard to the protective vaccination or inoculation against rabies, associated with Pasteur's name, there are many who contend, without casting any reflections on the memory or good faith of the distinguished founder of bac-

teriology, that his theory and method are so inseparably linked with the elements of possible error that they fail to convince, and that statistical results do not justify the practice. Pasteur maintained that his experiments proved that, in addition to the saliva and salivary glands, the spinal cord of a mad dog also contained the virus, and that inoculations with preparations of the cord, when introduced under the dura mater or lining membrane of the skull, after trephining, reproduced the disease in dogs and rabbits. He further satisfied himself that the virus, when propagated in this way through a series of rabbits, increases in intensity; so that, whereas inoculation under the dura mater from the brain or spinal cord of a mad dog takes from fifteen to twenty days, in successive subdural inoculations in a series of rabbits the incubation period is gradually reduced to seven days. Thus, spinal cords possessing varying degrees of virulence can be obtained throughout the whole series. When these cords are suspended in dry air their virulence can also be so attenuated until it finally disappears, so that further graduation in intensity is procured. Pasteur prepared his material for injection as follows, and it is the method still pursued:—Portions of these dried spinal cords are crushed in sterilised broth and injected under the skin; the injections commencing with cords dried for thirteen to fourteen days, and continued, after intervals of two days, until a series of fifteen injections are completed with cords dried for periods extending from fourteen to five days in carefully graduated series. In this way Pasteur experimented successfully with fifty dogs; and after finding that no symptoms of rabies could be produced by the bite of an infected dog, or by the injection of rabic spinal-cord matter under the skin, he felt himself justified in trying the experiment on a boy who had been bitten by a rabid dog, whose condition was such that the disease was believed to be incubating in his system. The boy did not take hydrophobia after treatment—indeed he might not have taken it in any case—and so Pasteur's system of antirabic treatment was inaugurated in 1885.

And now as to the elements of possible error which, to many unprejudiced minds, cannot help obtruding themselves. In the first place, it is contended that there is no clear proof that rabbits are made rabid by injections of spinal-cord virus "through minute holes bored in the skull into the space under the dura mater," because the only symptoms which they exhibit similar to those shown by dogs dying of rabies are "dumb" madness, hyperæsthesia with reflex spasms, and acute ascending paralysis or paraplegia, and these are the kind of symptoms which could be induced by the lesions caused by these subdural injections. For, according to Gowers, "organic brain diseases, accompanied by delirium and convulsions, occurring after a bite, have been mistaken for hydrophobia" in the human subject, "as in a case in which the nature of the disease was only discovered when, after exhumation, meningeal hæmorrhage was found" (see Quain's *Dictionary of Medicine*). In the second place, it is contended that the infective material used may not be specific, but only of varied septic power or virulence, and the immunity conferred on dogs injected subcutaneously is only the immunity which might be expected with such graduated injections. For it is significant that though both micrococci and bacilli have been found in the so-called rabic cord, no specific microbe has been isolated with certainty, and it is assumed that the protection obtained is due to some vague chemical substance. As the cords are not sterilised, but only exposed to dry air, the question has been raised whether it is not probable that these micro-organisms may not develop ptomaines of varying septic power. In the third place, it is admitted (*see* Quain) that distemper has sometimes been mistaken for rabies in dogs, and also tetanus, while "a ferocious dog has frequently been mistaken for a rabid one"; and further, that "there are no post-mortem signs sufficiently trustworthy or characteristic to enable us to form a correct diagnosis of rabies."

These last authoritative statements not only admit the possibility of error in the absolutely specific nature of the virus when experimentation was first started by Pasteur, or

may still be commenced by others *ab initio*, but they throw still greater doubt on the reliability of the statistics of preventive cure after a person has been bitten by a dog or other animal supposed to be rabid. Granted that the case mortality of hydrophobia is practically 100 per cent, the actual deaths from the disease are remarkably few. Thus, according to the Registrar-General's returns, the deaths recorded in London, where the greatest number of cases occur, were only two in 1890, two in 1891, none in 1892, one in 1893, and one in 1894; or, if the whole registered deaths are taken from 1837 up to 1894 inclusive, they do not exceed an average per year of 3·1, or, allowing for increase of population during all those years, an annual death-rate of a little over one per million of inhabitants. Moreover, while the mortality from hydrophobia is so infinitesimal, the numbers of persons bitten by dogs believed to be rabid, are enormous, and to assert, therefore, that the mortality from the disease has been reduced from practically 100 per cent to about 0·4 per cent by Pasteurism is, in the face of it, utterly fallacious.

In order, however, to be able to gauge the results of Pasteurism from a judicial point of view, it will be of advantage to scrutinise the statistics, not of the Pasteur Institute in Paris, but of a kindred establishment, say, that of the Pasteur Institute in Palermo, whose percentage mortality is practically the same as that of the Paris establishment, and was opened only a year later, namely in 1887. As is shown in the *Annales de l'Institut Pasteur* for 1896, the total number of patients treated at the Palermo Institute during the period 1887-1895 inclusive amounted to 2221. The "biting" animals consisted of 2066 dogs, 87 cats, 17 asses, 13 mules, 11 cows or oxen, 6 pigs, 2 wolves, 1 rabbit, and 1 horse, and there were 16 cases owing to "contact of recent injuries with the saliva of a rabid man."

Leaving aside those persons to whom treatment was refused, either because the biting animal was clearly not suffering from rabies, or because the bite was evidently

harmless, the 2221 "bitten" persons treated are classified as follows:—

Bites.	Animals certainly rabid.			Animals suspected of rabies.			Totals.
	Cauterised.	Not Cauterised.	Total.	Cauterised.	Not Cauterised.	Total.	
On the face . . .	17	52	69	17	29	46	115
On uncovered parts . .	237	467	704	147	350	497	1201
On covered parts, with tearing or perforation of clothing	184	283	467	182	256	438	905
Totals . .	438	802	1240	346	635	981	2221

Without commenting on the somewhat motley group of "biting" or infecting animals, it will be seen from the above table, that out of the total of 2221 patients, 1240 or 55·8 per cent were bitten by animals in which rabies was said to have been "proved experimentally," and 981 by animals in which rabies could only be inferred by the patients themselves or their friends, or from certificates furnished by local medical men or other authorities. Now, in respect to the animals proved to be rabid, the so-called proof consists in the development of rabies in other animals, such as rabbits, by inoculating them with broth decoctions of the spinal cords of the biting animals—a proof which can in no instance be accepted as conclusive, because, as already stated, there is legitimate question as to whether the symptoms so induced are those of rabies. Moreover, the very fact that such experiments on test animals are deemed necessary to prove the existence of rabies in the biting animals is in itself an admission that very little reliance is placed on post-mortem examination alone. But by far the greater proportion of the biting animals classified as certainly rabid include those certified to be rabid only on veterinary examination, which is thus seen to be discredited by Pasteurists

themselves, and, as has previously been shown, reveals no pathological appearances on which any certain opinion can be based. Indeed, it is well known that veterinary surgeons place most reliance on the presence of grass or other foreign substances in the stomach as indicative of rabies in the dog, but almost all dogs eat grass, when they have the opportunity, as a medicine, and young dogs especially are not at all particular about what they sometimes swallow.

As regards the large number of biting animals suspected to be rabid, amounting to 981, there need be no comment, beyond the statement that their inclusion weakens to a much greater degree the reliability of the results, and this reliability is still further affected when the numbers of the bitten patients who had their wounds cauterised, half of them with a red-hot iron, or were bitten, through "tearing or perforation of their clothing," are taken into account, because in either case these patients were more or less protected against the entrance of the virus into the system, assuming that some of the animals were rabid.

And now for the results. In respect to those 2221 patients treated in the Palermo Institute from its opening in March 1887 to the close of 1895, the following statement must be quoted:—"Leaving on one side five persons who died during the course of treatment, and five others who died within fifteen days of the termination of the treatment, we have only to deplore want of success in nine cases, which gives a mortality of 0·4 per cent." These results compare very closely with those obtained at the Pasteur Institute in Paris, inasmuch as out of a grand total of 17,337 patients treated from the opening of the Institute in 1886 up to the close of 1895, 86 deaths were recorded, showing a mortality of 0·39 per cent.

But admitting this low mortality, it is contended, for the reasons advanced, that the vast majority of the cases treated would never have developed hydrophobia, and further doubt is thrown upon the reliability of any of these statistics of prophylaxis or cure when it is stated that the deaths enumerated do not include those which occur during treat-

ment or within fifteen days after the last inoculation. It is assumed that all such deaths are due to the rabic poison developing in the system before inoculation ; but if, as Pasteur maintained, and his followers hold, the rabic poison is contained in the spinal-cord decoctions used in the treatment, what guarantee is there that some of the deaths from hydrophobia which occur during or after treatment are not due to the injections ? This alone is one of the gravest objections which have been raised against antirabic vaccination, and it does not appear, from an unprejudiced review of the many sources of error which have been alluded to, that it can ever be logically faced.

The results, however, may be scrutinised in another light. It was claimed by Pasteur, and is maintained by his followers, that on dogs the success of his method of treatment was invariable. But if the analogy between the experiments on dogs and the treatment of human beings is complete, all the deaths from hydrophobia which occur during or after treatment must be classed as failures, and according to the supplement of the *Zoophilist* for February 1898, the number of those deaths which have been traced amount altogether to 373. It is contended, therefore, that this number of deaths, and others which may have escaped notice, merely represent the number bitten by rabid animals who would have succumbed to the disease had there been no antirabic treatment, and that the thousands who have been treated and survive ran no risk of dying from hydrophobia had they never been subjected to treatment. The only risk which it appears they run, and this, it is granted, is a very remote one, is that they may suffer severely, or die from septic poisoning, but not from injection of rabic virus. In all this contention, however, it need hardly be said that whatever doubts are entertained as to the justification or even the legitimacy of the treatment after such extensive and prolonged trial, there can be no doubts as to the honesty of the views of those who carry it out, or of those who still uphold it, nor can any reflection be cast on the memory of the great Pasteur.

Brief reference may now be made to the possibilities of error, which, it is contended, militate against the justification of some other methods of protective or curative inoculation. Passing by the dismal therapeutic failure of Koch's tuberculin treatment for phthisis, which was hailed with such enthusiasm by the medical profession throughout the world, it will suffice to refer only to the antitoxin serum treatment for tetanus and diphtheria. With regard to the former, it is claimed that a specific bacillus has been discovered at the seat of infection in human tetanus which is the *causa causans* of the disease, but it is also admitted that the tetanus bacillus is found in garden soil, that is, manured soil, or indeed in filth of any kind, and this classes it as a saprophytic, as well as a parasitic, organism. By cultivating these bacilli in certain media, such as gelatin and the addition of a small percentage of grape-sugar, Kitasato succeeded in obtaining what he believed to be a pure culture, but it is noteworthy that when the spores or bacilli are washed and freed from antitoxins, these specific bacilli do not produce the disease in animals when injected subcutaneously, and are supposed to be destroyed by phagocytosis. If, however, graduated doses of cultivated bacilli are injected along with their toxins, an animal, such as a rabbit, may be made immune, and the blood serum of such immunised animals, it is maintained, acts as an antitoxin, and has been used as a cure for human tetanus by inoculation with successful results. Now, those who question the lines of research on which this method of treatment rests, throw legitimate doubt not only upon the specific nature of the bacillus, but assert that though the disease often proves fatal, death in the great majority of cases does not occur till between the seventh and eleventh days, and that there are many recoveries when ordinary remedies are adopted, which, even when antitoxin serum is used, are not neglected. They contend, therefore, that because a patient recovers it does not at all follow that recovery is due to these prophylactic inoculations, and that recovery is just as possible, and perhaps more assured, without them.

With respect to diphtheria, the difficulties in arriving at a sound conclusion in relation to serum-therapy are rendered still greater because the bacteriologist has arrogated to himself the absolutely correct diagnosis of the disease, namely, the presence of the Klebs-Löffler bacillus in the throat exudations—a bacillus which is admittedly found even in healthy throats as well as in the fauces of patients who have for weeks recovered from all other symptoms of the disease. Nor, again, must it be forgotten that there are other organisms found in the diphtheritic membrane, such as cocci, which were at one time believed to be specific, and microscopic diagnosis is further complicated by the presence of a pseudo-diphtheria bacillus identical in morphological respects with the true bacillus. It is admitted, too, that under certain conditions the so-called specific bacillus may lie dormant in soil for indefinite periods, and can be cultivated in soil, as well as in other media (see *ante*, p. 359). It is also a matter of ordinary medical experience that in all localised outbreaks of diphtheria, general and local symptoms vary greatly in intensity, some of the cases presenting only very mild symptoms of throat illness, while others prove rapidly fatal, and that as regards infectivity, all throat ailments are more or less infectious. In all this, it is contended that not only may errors in diagnosis creep in abundantly, but inasmuch as early treatment with antitoxin is made a condition of its success, the very delay, in forwarding swabs from the throat for bacteriological examination, in itself militates against the therapeutic benefits which are claimed for the treatment.

With regard to the experiments on animals which are assumed as conclusive evidence of the specificity of the bacillus, it is admitted that various animals react even with what are believed to be pure cultures of the bacilli, but though the bacilli are found active at the point of inoculation, they do not invade the blood or tissues. But Roux and Yersin showed further that after removal of the microbes by filtration, the toxin itself is still pathogenic, and produces the characteristic symptoms of the disease.

Here, however, there is again room for question. For instance, domestic cats, which are believed to suffer from the natural disease, when inoculated with a cultivated virus, or even with the exudation of diphtheritic membrane, do not exhibit any exudation on the fauces unless inoculated there, but develop a broncho-pneumonia, and subsequent paresis, with inflammation of the kidneys, and these pathological indications, according to Klein, should be accepted as evidence that the disease is *equivalent* to human diphtheria. Further, although it is now asserted that the specific bacilli neither enter the blood nor the internal organs, but only the toxins elaborated by them at the point of inoculation, Klein, in his experiments on cows, in connection with the milk outbreaks of Camberly and Yorktown, and of Enfield, found that by inoculating with a pure cultivation of the bacillus diphtheria, an eruption on the udders, as well as broncho-pneumonia, was produced, and that the fluid from the vesicles, and also the milk from teats on which there was no eruption, contained the same bacilli, with every precaution taken. Here surely there is a marked divergence between the earlier, and later, results of bacteriological research. Then, again, it has to be noted that the animal selected for the preparation of the serum, namely, the horse, if not altogether immune to the toxin, is said to be highly refractive, and beyond a slight swelling at the point of inoculation, which generally disappears in two or three days, the animal continues in good health during the process of complete immunisation, which lasts for two or three months. Considerable quantities of blood are then abstracted from the jugular vein from time to time, from which the serum is separated, and this is called anti-toxin serum. Klein, however, in experimenting upon a pony with cultures of the bacillus over a period of 150 days, during which twenty separate injections were made, produced swelling at the point of inoculation, and rise of body temperature after each injection, the intervals between injections being governed by the time occupied by the pony in recovering from the effects of the previous injection.

The serum from this animal was found at an early stage to possess equal potency with the antitoxin serum obtained from animals immunised by injections with toxins as prepared on the continent, but, curiously enough, the progressive increase of potency of the pony's serum was not maintained on further injection of the animal, and actually became less potent. (See *Report of the Medical Officer to the Local Government Board for* 1894-95.)

With regard to the protective power of diphtheria antitoxin, and of other sera, it will be fitting here to quote the judicial summary of Dr. Klein's researches, which Sir Richard Thorne submits in his report to the Local Government Board for 1895-96, and his own weighty conclusions. After referring to the two methods employed by Dr. Klein in obtaining serum from animals inoculated with the actual virus, or the sterilised culture virus, of the typhoid bacillus and Koch's cholera vibrio, as well as diphtheria bacillus, the report proceeds: "Each several serum employed by Dr. Klein served to protect his experimental animals against the diphtheria process for a limited period only, a period which in no case exceeded one week. Furthermore, the amount of serum required for inducing in rodents this condition of very temporary protection was relatively so large as practically to forbid anticipation of useful results from an application of the method to the human subject."

"In further elucidation of the source of the germicidal element thus demonstrated as present in blood serum, Dr. Klein studied in particular, and in regard of the typhoid bacillus and Koch's vibrio as well as bacillus diphtheriæ, germicidal serum obtained *solely* by injection of the intracellular substance of microbes. And he found, as he anticipated, that both typhoid serum and cholera serum, effective in each instance as a directly germicidal agent, may be readily obtained by injection of the experimental animal with the *sterilised protoplasm* of the one and the other microbe. He has not, however, yet tested the prophylactic, as contrasted with the directly

germicidal, potency of each such serum; but, in view of his experience in diphtheria prophylaxis, it may be suspected that, as protective agents, serums prepared in this way are by no means trustworthy. Indeed, in regard of most of the infections which so far have been under investigation in the above sense, a serum which may be relied on to afford any durable protection against attack is still a desideratum."

So much for the hopes entertained of discovering protective sera either against diphtheria, typhoid fever, or cholera, and there are equally strong grounds for believing that none of the protective inoculations, which are practised by Yersin, Haffkine, and others, are, or can be, effective. Indeed, in respect to animals which have been subjected to the widest possible range of experimental protection against disease, Virchow, perhaps the greatest living medical authority, has recently stated his opinion in the Prussian Diet, that "no sure prophylactic remedies against cattle diseases had hitherto been found." (See *Brit. Med. Journal*, May 7th, 1898.)

Brief reference may now be made to the claims made for diphtheria antitoxin as a powerful remedial agent—claims which many are not prepared to accept, notwithstanding the voluminous statistics which have been published both in this country and abroad in support of the treatment. Admitting that the statistics are in every respect reliable, and that the mortality has been considerably reduced, it is contended that this lowered death-rate may be accounted for in several ways:—(1) Outbreaks vary greatly in intensity, and it is only to be expected that, with improved and improving sanitary conditions, the disease is becoming much milder in type. This is markedly the case in respect to the allied disease scarlatina, whose case-percentage mortality during the last few years has become greatly reduced. (2) Assuming that every one who adopts the treatment believes in its efficacy, patients are necessarily watched more carefully to observe the effects of the antitoxin injections, and are therefore nursed more carefully; while if operation is deemed necessary, the surgeon approaches the case with

fuller confidence and greater promptitude. (3) If the patient is not a very young child, the hopefulness of cure entertained by the medical attendant, whether operative interference is deemed necessary or not, will be imparted to the patient, and exert a potent subjective influence towards recovery. In short, the mere injection of the antitoxin will act in many cases as a "faith-cure," which is admittedly a powerful adjuvant in all successful therapeutic treatment. (4) Local and constitutional remedies are not discarded; indeed it is only reasonable to assume that the medical attendant, in dealing with severe cases, would use all such remedies with a keener discrimination and more timely application, instead of yielding to an attitude of despair, as he formerly often did, because he had no sheet-anchor on which he believed he could rely.

Such are some of the more important reasons which may be advanced to account for the reduction in the mortality; while to many it seems clear that if this antidote, which admittedly possesses little, if any, prophylactic power, is a potent remedial agent, the reduction in the rate of mortality ought to be much greater than it has turned out to be, after such extended and protracted trial. Against all this it may be argued that no therapeutic agent could have been so widely accepted as a remedy unless backed by results, but it has all along only been largely adopted in hospital practice, and was just as enthusiastically hailed by the profession, especially on the Continent, as was tuberculin before statistical results had time to declare themselves. If it has not yet been accorded the verdict passed on tuberculin, many contend that it is because its ability to induce symptoms of blood-poisoning is not so marked. It is true that tuberculin has won for itself a seemingly permanent position in veterinary practice on the Continent as a diagnostic test for incipient tuberculosis in cows; but why, it is asked, is it discarded as a diagnostic test in incipient human phthisis, even if it proved a lamentable failure as a cure? The reason, as is well known, is that it produced such marked constitutional disturbances so closely resembling those of

septicæmia that the risks could no longer be faced. But similar risks attend the injection of diphtheria antitoxin, and here are some of them, as quoted from the *Medical Annual*, 1898 :—

Out of the 2764 cases of diphtheria treated with antitoxin in the Metropolitan Fever Hospitals during 1896, "a rash was found in 35·2 per cent, and was generally of an urticarial, erythematous, or scarlatinal type, whilst joint pains were noticed in 6·5 per cent, abscesses at seat of puncture in 1·2 per cent, and pyrexia (with or without rash or pain) in 19·8 per cent of the cases."

And again :—

"The most common ill effect of this remedy is an exanthematous rash. Hartung divides these into—(1) Serum urticaria ; (2) Diffuse serum exanthems ; (3) Scarlatinal-like rashes ; (4) Macula exanthems (measles, etc.) ; (5) Polymorphous serous exanthems. Borthwick and Irwin saw eight cases of this trouble in twenty-five, and it usually lasts about nine days ; in seven it was urticarial, and in one scarlatinal. Behring hopes to reduce all the unpleasant effects by the use of the new serum previously alluded to. Whilst there are still occasional lethal effects recorded, they are more probably due to an idiosyncrasy than to any unusual toxin in the serum. Cuno says, in the cases of acute nephritis, there was no evidence to show that there existed any direct connection between it and the injection. Goodall reports three cases of nephritis complicating diphtheria, treated with antitoxin, all recovering, and in two of the cases the nephritis existed previously to the injections, and in the third it reappeared, and this may have been due to the effect of the serum acting on the affected organ. He also says he has once seen hæmaturia after a serum injection."

Other serious ill effects are attributed to the use of antitoxin, and it is no satisfactory defence to throw the blame on unreliable sera, "unskilled hands," too great delay in administering the injection, too small a dose, and badly selected cases ; for it is admitted that the cases are selected, and that in itself tends to vitiate statistical results. Thus, to quote from *Aids to the Study of Bacteriology*, by Pearmain and Moore : "In mild or very severe cases not much advantage is gained by the treatment ; hence the remedy is—at present at any rate—more adapted for use in large institutions, where cases suitable for antitoxin treatment can be picked out, than in private practice."

One of the greatest advantages attaching to the treatment

is the fact that in severe cases the membrane is more rapidly loosened, thereby facilitating the operation of intubation. This, it is contended, is quite explicable, because the rise in temperature following upon the injection of the antitoxin will necessarily congest the minute blood-vessels under the membrane, and tend to act locally, just as a counter-irritant does, and as tuberculin acts in cases of lupus. Moreover, the very fact that the treatment is admittedly not suitable for mild or very severe cases throws profound suspicion upon the value of the remedy in any cases, while its restrictions to use in large institutions renders it comparatively valueless even if it were beneficial, because the vast proportion of cases of diphtheria which crop up are not treated in public institutions, but at their own homes. But even in respect to its application in hospitals it has by no means met with general acceptance in this country at all events, though, with one notable exception, it seems to be received as a legitimate and prized addition to the therapeutic armamentarium of the London Fever Hospitals. On the Continent, also, where serum-therapy treatment is practised to a much greater extent, numerous and serious notes of warning have been sounded, while at Dr. Koht's Children's Clinic at Strasburg University, to mention one instance, neither the serum treatment nor intubation is employed. The diphtheritic exudate is removed without laceration by local applications, and when operative interference is deemed necessary tracheotomy is performed, because intubated children cannot be easily fed.

The results of Dr. Koht's conservative treatment are as follows:—Out of 658 cases of diphtheria observed between 1889 and 1893 the mortality varied between 19·7 per cent and 26·6 per cent. Tracheotomy was performed upon 397 cases, and of these the mortality in different years ranged between 25 and 50·4 per cent. (See *Medical Annual*, 1898.)

In the second report of the Medical Superintendents of the Metropolitan Fever Hospitals, signed by all of them with the exception of Dr. Gayton, the following table is given to demonstrate the value of the antitoxin treatment, and

of the total cases admitted during 1895 and 1896, 71·3 per cent were so treated:—

Day of Disease on which Treatment was commenced.	Mortalities per centum.				
	1896.		1895.		1894.
	All cases.	Antitoxin cases.	All cases.	Antitoxin cases.	All cases. No Antitoxin.
First day	4·7	5·2	11·7	4·6	22·5
Second day	12·8	15·0	12·5	14·8	27·0
Third day	17·7	21·9	22·0	26·2	29·4
Fourth day	22·5	27·8	25·1	33·1	31·6
Fifth and after	24·6	31·7	27·1	35·7	30·8
Total	20·8	25·9	22·5	28·1	29·6
Tracheotomy cases	41·0	40·6	...	...	70·4
Laryngeal cases	29·6	28·8	...	...	62·0
Post-scarlatinal diphtheria	5·0	5·9	...	...	...

See *Medical Annual*, 1898.

Even this table, however, does not show on the face of it, except in respect to the first two days, such a large reduction in the rate of mortality when compared with the statistics of 1894, before the adoption of serum-therapy, as might be expected from a remedy supposed to be classed as specific; and certainly the results of the treatment do not appear to be superior to those of Dr. Koht's clinic. With regard to the 1894 statistics, too, it would be interesting to know whether the cases admitted were of a severer type than those admitted during the two later years, and whether or not the disease was so prevalent in London that cases were kept waiting for admission because the hospitals were too full. This, it is well known, has occurred on more than one occasion, and it does not, therefore, seem quite clear that the days given are actually the days of the disease, but only apply to the days of admission.

But it would be out of place to pursue this phase of the

subject farther, beyond pointing out, as many contend, that in bacteriological treatment or serum-therapy there is no guarantee that any culture, toxin, or antitoxin, and certainly not the broth decoction used in hydrophobia prophylaxis, can be regarded as absolutely pure, no matter what sterilising means may be adopted. For it is evident that all so-called pathogenic organisms cultivated in media can only be cultivated by the reduction of organic matter to other compounds, whether they be called toxins, or ptomaines as in food-poisoning, because outside a living host they can only thrive as non-pathogenic organisms do, by feeding on this matter and elaborating allied products, even though it may be granted that these products may retain varying degrees of specificity attaching to the organisms themselves. In experimenting on animals, therefore, there can be no assurance that an attenuated virus or toxin does not contain the usual septic products of decaying organic matter, and also the micrococci attaching to them which filtration will not remove; nor can there be any guarantee that in preparing, storing, and injecting sera the intrusion of these septic organisms and their products can be prevented. Indeed, in respect to Koch's new tuberculin, Dr. Jamieson of New York has recently forwarded a communication to the *British Medical Journal* (see No. 1949, May 7th, 1898), which not only shows that it is not always sterilised, but that it actually contains these putrefactive and other organisms. Dr. Jamieson gives the following short abstracts from the writings of well-known authorities:—

1. Maragliano (*Compte Rendu Hebd. Soc. de Biologie*, June 18th, 1897) found that two guinea-pigs out of seven treated with Koch's "T.R." became infected with tuberculosis; he also found other micro-organisms in the tuberculin.

2. G. Schroeder (*Münch. med. Woch.*, June 20th, 1897) found a few tubercle bacilli in two vials of tuberculin R. and pneumococci, yeasts, etc., in all vials opened. Three cases lost ground under treatment with "T.R."

3. Trudeau and Baldwin (*Medical News*, August 28th, 1897) found that out of five guinea-pigs treated with the new tuberculin "T.R.," two became infected with tuberculosis, and thirty-four vials

out of sixty-four were contaminated with yeasts and other micro-organisms.

4. Huber (*Berlin. klin. Woch.*, No. 1, February 14th, 1898) found tubercle bacilli and staphylococci in the "T.R." ; also two guinea-pigs became infected with tuberculosis without having been inoculated in any other way. He also failed to get any immunity with the tuberculinised animals, the controls living longer.

5. Burghart (*loc. cit.*) in a case treated with tuberculin R. found a cold abscess at site of inoculation, the pus from which contained only tubercle bacilli: he did not test the pus on guinea-pigs to see if the tubercle bacilli were living.

He further adds:—"Besides the above, numerous observers have reported contamination from streptococci, staphylococci, yeasts, etc., in previously unopened vials of 'T.R.'"

In the face of these statements, Koch's tuberculin can no longer be advocated as a cure for tuberculosis in man, or even as a reliable test for the disease in cattle. Notwithstanding the recent recommendations of the Royal Commission on Tuberculosis, that it should be used as a test for keeping cowsheds clear of the disease, the presumption would appear to be that animals react solely because their health is deranged, and not because they are actually infected, or have a hereditary tendency to the disease. It is further contended that in respect to test animals, injection into the peritoneal cavity, of the virus or toxin of any disease, such as tuberculosis, cholera, enteric fever, etc., tends to vitiate any conclusions which may be based upon them, on account of the varying intensity of the inflammatory symptoms likely to be induced on the delicate peritoneal lining, just as would the injection of Pasteur's decoction into the skull, on the lining membranes of the brain.

Of course it may be urged that septic risks attend the use and storage of vaccine lymph, but in arm-to-arm vaccination, with clean instruments and clean arms, there is no such risk, nor is there any in storing the lymph taken direct from the vaccine vesicle in hermetically-sealed capillary tubes. Again, with regard to storage of the lymph on ivory points or on scabs, the drying and exposure to the

air are in themselves potent antiseptic agencies. It is true that the preparation of glycerinated calf-lymph, which will be referred to subsequently, is not without its remote risks unless the greatest precautions are taken; but it is admitted that the glycerine destroys all cocci in the lymph, and therefore acts as an antiseptic without affecting the potency of the lymph. There are no broth or other cultures, and any lymph tinged with blood is rejected. But in respect to these other methods and preparations, the conviction cannot help obtruding itself on the open mind that the prominent symptoms induced by inoculation of animals or man by a cultivated virus, a toxin, or an antitoxin, are pyæmic or septicæmic rather than specific; and further, as already stated, that bacteriological treatment, Pasteurism, or serum-therapy bear not the slightest analogy to the protection or prophylaxis afforded by the matter of vaccinia against small-pox.

Jenner's great discovery has almost from the very outset received the strong, and, with the rarest exceptions, the universal support of the medical profession, but these more recent methods, which are admittedly based upon its *rationale* and success, have failed to convince vast numbers in the ranks who have as eagerly hoped for protection and cure in this direction as those who still earnestly and honestly uphold or practise them. Moreover, there are not a few who doubt whether all the agonies inflicted on animals sacrificed in the laboratories of continental workers in bacteriological research, or even in those at home where the use of anæsthetics is enjoined, have saved one single human life, or lessened in any appreciable degree the load of human suffering.

But without entering further into the polemics of this phase of the subject, there can be little question that the keenness of bacteriological investigation and experimentation on animal life has threatened of late years to ignore or minimise those factors of environment and dangers, which, from the view of practical sanitation, still remain of paramount importance, namely, pollutions or infections of

air, water, and food, and reckless dissemination of contagia. These contagia, whatever opinions may be held as to their nature or characteristics, are in many diseases air-borne, and enter the system by the respiratory tract, as in small-pox, scarlatina, diphtheria, whooping-cough, measles, typhus fever, relapsing fever, influenza, mumps, and epidemic pneumonia; others, as illustrated in previous chapters, may be conveyed by food or water, as well as by air, and act primarily on the intestinal tract, as in enteric fever, diarrhœa and dysentery, cholera, and yellow fever, and in respect to milk, scarlatina and diphtheria; some invade the system usually by direct inoculation, as in vaccinia, glanders, foot-and-mouth disease, syphilis, anthrax, and rabies; while others, again, enter by a surface lesion, or may be air-borne, such as septicæmia, hospital gangrene, erysipelas, and puerperal fever.

And here it may be observed that as the terms infection, contagion, and inoculation are used somewhat loosely in respect to the mode of propagation of communicable diseases, their definition as generally understood is nevertheless of some importance. By infection, then, is meant the conveyance of the virus of a disease in some indirect way, as through the various media of air, water, food, or fomites, into the body, and without any surface lesion; by contagion is meant transference of the virus by actual contact, and also without any breach of surface; while inoculation always implies breach of surface, whatever be the mode of conveyance of the virus into the system.

With regard to the incidence or prevalence of communicable diseases, the term *endemic* is applied to a disease when it is more or less restricted to a particular locality, and, owing to local causes, exhibits a tendency to linger or reappear in the district. The term *epidemic*, on the other hand, refers to a disease which breaks out suddenly and spreads widely; but some diseases, such as plague, cholera, and yellow fever come under both categories. Another term, *sporadic*, is applied to diseases such as enteric fever or diphtheria, which often crop up in isolated cases, and when it is

difficult or impossible to trace them to previously existing cases.

In describing briefly the distinctive features, etiology, and mode of propagation of the more important communicable diseases which are of chief hygienic concern, it will be convenient, without attempting any scientific classification, to discuss in order—(1) what are called the seven principal zymotic diseases; (2) other zymotic diseases, such as cholera, influenza, epidemic pneumonia, etc.; (3) several diseases which are common to man and animals, as anthrax, tuberculosis, and glanders; (4) parasitic diseases; and (5) certain infectious skin diseases.

Section II.—Infectious and Parasitic Diseases

Group I.—The Seven Principal Zymotic Diseases

The following table gives the chief points of comparison connected with the seven principal zymotic diseases, with the exception of diarrhœa and dysentery:—

[Table

Seven Principal Zymotic Diseases.	Period of Incubation.	Appearance of Eruption if any.	Period of Infection.
1. Small-pox	12 to 14 days (Usually 12 days).	2nd or 3rd day on face and forehead.	3 to 7 weeks, or till every scab falls off.
Chicken-pox	10 to 14 days (Usually 12 days).	1st to 4th day of fever on trunk and shoulders.	4 weeks ; until every scab has fallen off.
2. Measles	10 to 14 days (Usually 12 days).	4th day of fever on forehead.	During premonitory symptoms, and till end of desquamation.
Rötheln	7 to 15 days (Usually 14 days).	1st to 4th day of fever on face.	Same as Measles.
3. Scarlatina	1 to 7 days (Usually 3 to 4 days).	2nd day of fever on trunk.	End of desquamation, and complete disappearance of throat symptoms, as well as of any sores.
4. Diphtheria and Membranous Croup	1 to 10 days (Usually 2 to 3 days).	No eruption.	Until all discharges have ceased, and throat symptoms have disappeared.
5. Whooping-Cough	4 to 14 days (Usually 7 days).	,,	During catarrhal stage, and so long as whoop lasts.
6. Fevers—			
(1) Typhus	6 to 14 days (Usually 12 days).	5th to 8th day of fever on back and sides.	While fever lasts.
(2) Enteric	8 to 20 days (Usually 12 days).	Spots on abdomen, if any, between 6th and 14th day.	Till febrile symptoms disappear and diarrhœa ceases.
(3) Continued	Indefinite	No eruption.	Till all febrile symptoms disappear.
(4) Relapsing	4 to 10 days (Usually 6 days).	,,	Until relapses cease.
(5) Puerperal	Indefinite	,,	...
7. Diarrhœa and Dysentery	1 to 4 days	,,	...

1. *Small-pox.*—At what period small-pox was first introduced into this country history does not enlighten us, but according to authentic records it certainly existed both here and on the Continent prior to the ninth century, and there are notices of severe epidemics from the twelfth century onwards. Indeed, after the disappearance of the plague, it became the severest scourge of the country, and so late as the close of the last century, the deaths from this disease alone exceeded 10 per cent of the total number of deaths. As stated in the introductory chapter, the practice of inoculation introduced into this country on the representations of Lady Mary Wortley Montagu about the year 1720, while it modified the severity of the attack, assisted rather than otherwise, the spread of the disease itself, and it was not till some time after Jenner's grand discovery of vaccination, in 1796, had become general throughout the country that the gradual decline in the rate of mortality began to make itself apparent. Previous to the introduction of vaccination, it spared neither age, sex, nor position in life; every fifth person attacked died, and many of those who survived were hideously disfigured or maimed for the rest of their days. There is probably no disease so infectious, and none in which the infective material appears to operate at so great a distance, although, as pointed out in the previous chapter, the view that it can be disseminated by aerial convection over wide areas is open to question.

The period of incubation varies from twelve to fourteen days, and the fever is ushered in with shivering, headache, pain in the loins, and often vomiting. These symptoms vary according to the severity of the attack, but the central pain in the lumbar region, and vomiting are especially characteristic of the disease. The shivering is followed by fever more or less acute, and in severe cases delirium may set in within twenty-four hours. On the third day, a papular eruption appears on the forehead, neck, and hands and afterwards on the trunk and legs. If these papules remain separate and distinct, the disease is designated *variola discreta* or simple small-pox; but if they are so

numerous as to coalesce, the case is known as one of confluent small-pox, or *variola confluens*. In hæmorrhagic, black, or malignant, small-pox, the patient may succumb before there is any distinct eruption beyond a bright red stippling of the skin, most abundant on the lower part of the abdomen and thighs, which deepens into a dusky violet hue, accompanied often with flea-bite petechiæ, and hæmorrhage from the mucous surfaces.

In the discrete form of the disease, the papules become vesicles on the third day, surrounded by an inflamed area. On the fifth day, the vesicles become pustular, and the pustules subsequently become depressed in the centre or umbilicated; while on the ninth or tenth day, they break and form scabs which, as they shrivel and dry up, begin to fall off about the fourteenth day of the fever.

In *variola confluens*, the initial symptoms are more intense; the vesicles run into each other, and the face becomes very much swollen. After they become pustular, large black scabs are formed, and the characteristic odour of small-pox, which can be detected even in the discrete form of the disease, becomes sickening in the extreme. The mucous membranes of the mouth, larynx, and trachea are involved, and there is huskiness of voice and difficulty in swallowing. In severe cases it takes several weeks before desquamation is complete, while in both forms of the disease, it may be laid down as a safe rule that no patient should be pronounced free from infection until all the pustular crusts have fallen off, and the whole surface of the body has been repeatedly well sponged with warm water and some disinfectant soap, or several warm baths have been taken. After exposure to infection, a quarantine of seventeen days, to allow of a wide margin, is sufficient.

The infection of small-pox exists throughout the whole course of the disease. The exhalations, the vesicles, pustules, and scabs are all highly infectious. Moreover, the contagium is contained in everything that leaves the body; it may be conveyed by articles of clothing, bedding, books, etc., and may remain infective for long periods. As Dr. Parsons has

reported to the Local Government Board, it is undoubtedly sometimes imported in bales of rags, and has given rise to outbreaks of the disease among the workers in paper and shoddy mills. There can be no doubt, too, that it can be transmitted by dead bodies, if not properly disinfected.

Although the stage of the disease at which the virus is first generated in the person of the sick has not been accurately determined, there can be no question that so soon as a case is diagnosed or suspected, precautionary measures should forthwith be adopted. Unfortunately, however, it sometimes happens that isolated cases of the disease are mistaken for cases of chicken-pox or German measles, and prompt and effective measures are neglected. In my own district, I have had to investigate several outbreaks in which errors in diagnosis of this description have been made, and I have also been consulted in a few cases when the disease turned out not to be small-pox, as suspected, but either chicken-pox or measles. Of course it is often very difficult to diagnose with certainty isolated cases of any one of these diseases, and hence it is very essential that not only should the character of the eruption be carefully scrutinised, but the premonitory and other symptoms, as well as the probable source of infection, should also be inquired into. Above all, the arm should be examined as regards the character of the vaccination marks, if any. In cases of modified small-pox showing good vaccination marks, the papules are often not only sparse, but soon abort and disappear; and I have seen a very characteristic outbreak of this modified form of the disease among workhouse children, all of them showing fairly good vaccination marks, in which there was no difficulty in accounting for the outbreak, or in deciding as to the nature of the disease.

In *Varicella* or chicken-pox the premonitory symptoms are slight; while the papules, which generally appear first on the trunk and shoulders, become converted into vesicles on the second day, and dry up about the fourth. The vesicles are usually globular in form, translucent in appearance, have no central depression, and collapse on pricking.

Small-pox vesicles, on the other hand, are flat and circular in form, always depressed in the centre, and, being multicellular in structure, do not collapse on pricking. Moreover, chicken-pox is much more a disease of early childhood. Varicella occurs as an epidemic, but beyond the period of incubation and a certain superficial resemblance, there is nothing common between the two. If, however, small-pox is prevalent in the neighbourhood, any case presenting symptoms which are assumed to be those of chicken-pox should be regarded with suspicion, and especially if the patient is an adult. Small-pox is occasionally ushered in by eruptions which simulate those of measles, scarlatina, or erysipelas; but if the disease be small-pox, the eruption will show characteristic features within twenty-four hours, or will show signs of malignity. Of eruptive diseases, purpura hæmorrhagica, acne, erythema, urticaria, and secondary syphilis have been sometimes mistaken for small-pox, but mistakes of this kind may in most cases be avoided by a careful consideration of the history of the case.

The precautionary measures to be taken so soon as a case of small-pox is diagnosed are briefly these:—The patient, if not at once removed to a hospital, should be carefully isolated, and the house quarantined as far as possible. All persons living in the same house or adjoining houses, over ten years of age, unless protected by a previous attack of small-pox, should at once be revaccinated, and likewise all children under ten whose vaccination marks are not large and distinct. Any unvaccinated children, however young, should at once be vaccinated. (See Memorandum of Local Government Board in Appendix.)

Vaccinia and *Vaccination*.—Vaccinia or cow-pox, which is a natural, though not common, disease of the cow and horse, never occur spontaneously in man; it is only communicable by the direct inoculation of its own specific virus. Previous to Jenner's time such inoculation was never more than a mere matter of accident, and was by no means of common occurrence. It was matter of popular tradition, however, that persons who had been accidentally vaccinated

when milking cows suffering from the disease enjoyed subsequent immunity from small-pox, and it was Jenner's great discovery that the cow-pox, once implanted in the human subject, could be continued by inoculation from person to person indefinitely, which rendered the practice of vaccination possible. Although cow-pox was formerly common, it has become rare among cattle coincidently with the reduction of small-pox due to vaccination. The seat of the eruption is the teats and udders of cows, and this limitation suggested contact with the hands of milkers as a means of inoculation.

But the question has been warmly contested as to whether vaccinia is a disease common to animals, or a modification of what in man is known as small-pox. Many leading authorities, such as Simon, Bristowe, Hutchinson, and Seaton maintain the latter view, while there are others who are strongly of opinion that cow-pox and small-pox are essentially distinct diseases. There is no doubt that it is exceedingly difficult to inoculate cows successfully with human small-pox. Many continental observers, however, claim to have accomplished such inoculation, and in this country Klein, Copeman, and Simpson have also succeeded in obtaining variolated lymph, after transmission through a series of calves, which yields results in human vaccination identical with those obtained from true vaccine lymph. But apart from these experiments, there can be no question concerning the protection which vaccinia confers against small-pox, and the similarity which certain of its features bear to those of small-pox affords presumptive evidence that the vaccine virus is an attenuated form of the varioloid virus.

In the early days, vaccination was believed to confer complete immunity against small-pox, but it has long since been admitted that such protection is only partial. After even a limited number of years a vaccinated person, if exposed to a strong dose of the varioloid poison, runs considerable risk of contracting small-pox. Cases have come under observation which go to prove that even a first attack does not always protect, and this has been found to apply to persons who have suffered from small-pox, for Wynter Blyth states that he has

himself seen a person, pitted from a former attack, contract a second and die. (See *Manual of Public Health.*)

Although the practice of vaccination became pretty general in the early part of the century, it was not till 1838 that it was provided gratuitously by the Government, not till 1854 that it was made compulsory, and not till 1871 was it systematically enforced by paid vaccination officers. That each of these extensions of vaccination has been followed by a marked reduction in the small-pox mortality is clearly proved by the statistics submitted to the Commission on Vaccination. Thus, in the Forty-third Annual Report of the Registrar-General, it is shown that during 1838 to 1853, the death-rate from small-pox was 305 per million; during 1854 to 1871, it averaged 223 per million; while from 1872 to 1891, the average death-rate has been still further reduced to 89 per million. Notwithstanding these figures, however, anti-vaccinators are constantly asserting that the great reduction in the small-pox mortality rate is in reality due to improved sanitation; but, as Dr. Ogle, late Superintendent-Registrar, has pointed out, this assumption is controverted by other statistics, for while the death-rate during the periods in question has declined 9 per cent, that of small-pox has decreased 72 per cent; and this decrease is by no means equally shared by people at all ages, which should be the case if attributable to improved sanitation only. This is shown in the following tabular statement:—

During the first 5 years of life the mortality has fallen		85	per cent.
From 5 to 10 years	,,	64	,,
From 10 to 15 years	,,	27	,,

Over fifteen years of age the mortality from small-pox has actually increased, owing to the fact that the protection afforded by vaccination greatly diminishes as puberty approaches.

But the most convincing proof of the value of vaccination is afforded by the statistics of recent epidemics, and notably those of Sheffield and Gloucester. The Sheffield epidemic of 1887-88 was investigated by the late Dr.

Barry, one of the medical inspectors of the Local Government Board, and his voluminous report testifies to the elaborate care with which the inquiry was conducted. Special instructions were given to Dr. Barry to inquire into every influence which could possibly bear upon the incidence of small-pox in Sheffield, but no influence was discovered beyond the single dominating influence of vaccination. The tabulated results are as follow :—

	Per 1000 Persons of each Class stated.			
	Attack-rate.		Death-rate.	
	Vaccinated.	Unvaccinated.	Vaccinated.	Unvaccinated.
0-10 years	5	101	0·09	44
Ditto, living in invaded houses	78	869	1	381
Over 10 years	19	94	1	51
Ditto, living in invaded houses	281	686	14	371
All ages	15·5	97	0·7	48
Ditto, living in invaded houses	230	750	11	372

In this table the figures represent the rates per 1000 of the child population under ten years, of persons over ten years of age, and of persons of all ages; first, as applying to the population of the borough generally; and secondly, as applying to the enumerated population of the invaded houses. From these statistics it appears that "the vaccinated children had, as compared with the unvaccinated children living in the town, a 20-fold immunity from attack by small-pox, and had a 480-fold security against death by small-pox; that in the invaded houses the vaccinated children had, as compared with the unvaccinated, an 11-fold immunity from attack by small-pox, and a 381-fold security against death by small-pox"; and that, as regards all ages, the vaccinated among the population generally had, as compared with the unvaccinated, a 6-fold immunity against attack, and a 64-fold immunity against death. (See Dr. Barry's Report, 1889.)

But still more instructive is the lesson of the Gloucester

epidemic, which broke out towards the close of 1895, and was traced to a case of small-pox in an unvaccinated child which had been concealed and treated as measles. Indeed, the special feature of this epidemic was the exceedingly large number of unvaccinated children which had been accumulating for several years prior to the outbreak. This neglect of vaccination was the outcome of the successful agitation of a small but energetic body of anti-vaccinators, who so influenced the election of the Board of Guardians that in 1887 they had a majority on their side, and a resolution was passed to the effect "that the vaccination officers take no further steps in vaccination prosecutions until authorised by the Board." To quote from Dr. Bond's most interesting pamphlet, "The Story of the Gloucester Epidemic of Small-pox":—"The effect of the resolution of the Gloucester Board in 1887 by which they practically suspended compulsory infantile vaccination in their district, soon became evident. The following tabular statement of the decline of the public vaccinations will show how soon the class of the population for whose benefit gratuitous vaccination is provided began to take advantage of the option which was thus offered to them:—

	Total Vaccinations.
1886	1095
1887	472
1888	140
1889	95
1890	60
1891	34
1892	39
1893	38
1894	34
1895	371
Total vaccinations in 10 years	2378
Do. in 9 years (1887-95)	1283

"During these ten years 15,682 children had been born in Gloucester, of whom 3176 had died, leaving a balance of 10,128 children to be accounted for. This fact is a sufficient answer to the statement that Gloucester at the time of the outbreak of the epidemic was, so far as its juvenile population was concerned, 'not generally an un-

vaccinated city.'[1] Nor is there any pretence for assuming that, in regard to its adult population, Gloucester was any better protected than other towns in the Kingdom. Probably it was worse; for the disbelief which had discouraged primary vaccination was not likely to lead to anything but decreased care in renewing the protection which those who had been vaccinated in infancy more or less enjoyed."

"It is important, also, to note that during these ten years, as well as for the twelve which had preceded them—that is to say, since 1873, when Gloucester was visited by the epidemic which prevailed generally throughout Western Europe—the city had been practically free from small-pox."

It may here be explained that all the statistics which appear in Dr. Bond's pamphlet were attested, not only by the most careful local scrutiny, but also by Dr. Copeman of London, who was deputed by the Royal Commission on Vaccination to inquire into all the circumstances of the epidemic. Briefly then, the total population of Gloucester and the suburbs involved in the outbreak was estimated at 42,000, and the total number of cases recorded amounted to 2035. This total was made up as follows:—

Vaccinated in infancy	1208
Unvaccinated	789
Uncertain	38
	2035

With regard to the age incidence of the attacks, the following table is given:—

Attacks

	Under 10 years.	10 to 20 years.	20 years and over.	Total.
Vaccinated in infancy	23	269	916	1208
Unvaccinated	699	51	39	789
Uncertain	1	2	35	38
	723	322	990	2035

[1] "See Statement of 'Four Facts,' issued by the Anti-Vaccination League, with the view of explaining away the Experience of Gloucester."

The relations of these figures are rendered still more striking when stated as percentages of the total numbers.

	Under 10 years.	10 to 20 years.	20 years and over.	Total.
Vaccinated in infancy . .	1·9	22·2	75·8	59·3
Unvaccinated	88·6	6·4	4·9	38·7
Uncertain	2·6	5·2	92·1	1·4
	35·5	15·8	48·6	99·4—9

Leaving out the uncertain cases, it is seen from the last table that whilst 98 per cent of the attacks in the vaccinated occurred over ten years of age, and more than 75 per cent over twenty years of age,—more than 88 per cent of those in the unvaccinated were under ten years, and less than 12 per cent were over twenty years. These figures prove conclusively that vaccination does afford a very high degree of protection against attack up to ten years of age, but that this protection exhibits a falling-off in efficiency between ten and twenty years, and a great decline from this latter age upwards.

"But," continues Dr. Bond, "the strongest evidence which the figures of the Gloucester epidemic afford as to the protective value of vaccination is derived from a consideration of the relations of age incidence to the mortality of the attacks, *i.e.*, the relative *fatality*. And first let us examine the

Mortality Statistics

Deaths

	Under 10 years.	10 to 20 years.	20 years and over.	Total.
Vaccinated in infancy . .	0	11	102	113
Unvaccinated	281	14	18	313
Uncertain	0	1	16	17
	281	26	136	443

"From these figures two very striking facts are evident. The first is that whilst no less than 281 unvaccinated children under ten died, there was not a single death of a vaccinated child under that age. The second is that whilst the number of attacks in the three age periods of the vaccinated class is roughly in the proportion of 1 : 11 : 40, the *severity* is in the proportion 0 : 11 : 102 ; that is to say, whilst a person over twenty years of age who has been vaccinated in infancy has, on an average, forty times the chance of being attacked by small-pox that a child under ten has, he is exposed to a good deal more than one hundred times the chance of dying from it."

"But the true test of the effect of vaccination in infancy on the severity of the attacks can only be obtained by estimating the *fatality* of the attacks—that is the proportion *per cent* of those who die to those who are attacked, in both cases. The following table gives the evidence on this point :—

FATALITY STATISTICS

Percentage of Deaths

	Under 10 years.	10 to 20 years.	20 years and over.	General average.
Vaccinated in infancy .	0	4·1	11·1	9·3
Unvaccinated . . .	40·2	27·4	46·1	39·9
Uncertain . . .	0	20·0	45·7	44·7
	64·1	5·9	30·7	*mean fatality* 21·7

"From these figures it follows that whilst the odds against a person who has been vaccinated in infancy dying from small-pox cannot be estimated for ages under ten years, so far as the experience of the Gloucester epidemic goes, because no vaccinated child under that age died out of the twenty-three who were attacked, 40 per cent of the unvaccinated children who were attacked by the disease perished."

"If we dissect the figures of the vaccinated children more minutely still, we obtain corroborative evidence of the protective effect of vaccination in early life, for of the twenty-three children under ten who were attacked, none were less than seven years of age, two were under eight years, nine were under nine years, and twelve were under ten years old. Moreover, seventeen of these twenty-three are reported to have had 'mild' attacks, one 'very mild,' three had 'moderately severe,' and only two had it in the 'confluent' form."

Another important fact which a more minute dissection of the figures disclosed, is the great increase in the fatality of the disease as age advances in persons who have not been vaccinated in infancy. Thus, while the fatality from ten to twenty years is only 4 per cent, it steadily rises until at seventy years it was found to reach 25·7 per cent.

With regard to the effects of vaccination and re-vaccination in suppressing the disease, the following brief review of the story of the epidemic is necessary:—Up to the close of 1895, only thirty-one cases had come under notice, and indeed up to the end of January 1896, the epidemic, though incubating, was still under control because all of the fifty-nine cases notified had been removed to hospital. During February, however, the number of cases notified mounted up to 146; during March, to 644; whilst in April, the high-water level of 744 was reached. On 24th March, the Board of Guardians practically rescinded the mischievous resolution of 1878, and instructed their officers to carry out the provisions of the General Order of the Local Government Board of 1874 relating to vaccination. But long ere this, though huts were erected and schools converted into hospitals, the means of isolation could not cope with the epidemic, and as a matter of fact only 700 out of the total of 2000 cases approximately were removed.

Meanwhile vaccination and revaccination had been carried out to some extent on persuasive and voluntary lines, and vaccination by calf-lymph was offered free to all who would accept it. But all these agencies proved in-

effectual to stay the plague, and at last, on 27th April, a committee was appointed to organise and carry out the general vaccination of the city and district. This committee secured the services of three experienced assistants to take charge of the whole work; eight qualified practitioners, one of them a lady, were appointed to assist the public vaccinators; a central office was opened; a staff of clerks and vaccination inquirers was engaged; the city and suburbs were marked out into districts for the purpose of inquiry; and the public were duly notified, by various means, of the arrangements which had been made. Within a few days of the opening of the campaign, every house in the city and suburbs was visited, a vaccination census of the whole population was taken, the vaccinators were sent wherever their services were required, and by the end of June the vaccination and revaccination of all who could be induced to voluntarily submit themselves and their children to the operation had been effected. A few recalcitrants were summarily dealt with, but the conversion of Gloucester to Jenner's doctrine was practically complete. From first to last upwards of 36,000 persons were vaccinated or revaccinated, and the results of this strenuous systematic action on the progress of the disease were conspicuous from the outset. The rapid extension of the epidemic was at once arrested, and by the end of July it was stamped out altogether. But, as the report states, at what a cost? The 443 victims of the epidemic could be enumerated, but who could gauge the untold distress, suffering, and remorse of relatives, or the less keen, though more widely-spread, misery, attending the illnesses of the 1600 who escaped with their lives? As to the money loss entailed, it was estimated at £150,000, and the immediate outlay falling upon the rates at £17,000.

It need hardly be said that all through the epidemic the anti-vaccination propagandists continued to proclaim their doctrine that the magnitude of the epidemic was entirely due to overcrowding and insanitary conditions generally, and was in no degree attributable to the neglect of vaccination. But the fact remains that Gloucester, which

at the date of the outbreak was one of the worst protected localities, was, at its close, perhaps the best vaccinated town in England. From 1st January 1896 to 8th August the number of cases vaccinated and revaccinated, as ascertained from all sources, was as follows:—Primary vaccinations, including 1072 children under ten said to have been vaccinated in infancy, 9616; revaccinations, 26,364; total, 35,980.

If special prominence is given to the statistics of this epidemic, it is because the details may be of service to many who may soon have to face severe outbreaks of the disease as well as to combat the unwarrantable statements and fallacies of the Anti-Vaccination League; and to equip them still further for this, reference may be made to the exceedingly useful pamphlets published by the Jenner Society, of which Dr. Bond, of Gloucester, is the Honorary Secretary.

As already stated, the unique feature of the Gloucester epidemic was the excessive proportion of unprotected children, and it proved conclusively that, as in pre-vaccination days, the heaviest incidence of smallpox was upon childhood, in the unvaccinated portion of the community it remains so still. In its other aspects, the epidemic confirms very fully the conclusions of the Royal Commission on Vaccination, based on the enormous bulk of evidence submitted to them, which are as follows (see Report of Royal Commission and Dr. Bond's pamphlet):—

"(1) Vaccination diminishes the liability to be attacked by small-pox.

"(2) It modifies the character of the disease, and renders it (*a*) less fatal and (*b*) of a milder type.

"(3) The protection it affords against attacks of the disease is greatest during the years immediately succeeding the operation.

"(4) After the lapse of the period of the highest protective potency, the efficacy of vaccination to protect against attack rapidly diminishes, but it is still considerable during the next five years, and possibly never altogether ceases.

"(5) The power of vaccination to modify small-pox is

also greatest in the period in which its power to prevent from attack is greatest, but its power thus to modify the disease does not diminish as rapidly as its protective influence against attacks, and its efficacy during the later periods of life to modify the disease is still very considerable.

"(6) That revaccination restores the protection which lapse of time has diminished.

"(7) The beneficial effects of vaccination are most experienced by those in whose case it has been most thorough."

Although there was no precise statistical evidence collected during the Gloucester epidemic to confirm the last conclusion, which refers to the number, area, and character of the cicatrices, it has been fully endorsed by the statistics of all large small-pox hospitals, and particularly by the following statistics collected by Marson and Gayton:—

Case Mortality in relation to number of vaccine cicatrices. (MARSON.)

	Case Mortality (per cent)
Unvaccinated	35½
Stated to be vaccinated, but without cicatrices	21¾
Having one cicatrix	7½
Having two cicatrices	4⅛
Having three cicatrices	1¾
Having four or more cicatrices	¾

Case Mortality in relation to quality of vaccination and to age, based upon an analysis of 10,403 *cases in Metropolitan Small-pox Hospitals.* (GAYTON.)

Ages.	Vaccinated. Good Marks.			Vaccinated. Imperfect Marks.			Said to be Vaccinated. No Marks.			Unvaccinated.		
	Cases.	Deaths.	Case Mortality.	Cases.	Deaths.	Case Mortality.	Cases.	Deaths.	Case Mortality.	Cases.	Deaths.	Case Mortality.
0–5	51	0	0·0	182	21	11·5	128	47	36·7	677	383	56·6
0–10	267	2	0·7	714	48	6·7	325	87	26·8	1187	563	47·4
10–20	1045	17	1·6	1976	98	5·0	419	81	19·5	521	160	30·7
20–40	725	37	5·1	1898	258	13·6	420	140	33·3	382	181	47·4
Over 40	48	6	12·5	266	51	19·2	131	44	33·8	79	34	43·0
All ages	2085	62	3	4854	455	9	1295	352	27	2169	938	43

Although there is no doubt that pending legislation will alter the age limit, the existing Vaccination Acts require that every child shall be vaccinated within three months of

its birth unless (1) the child dies within this period; or (2) the state of health renders postponement necessary; or (3) the child is attacked by small-pox; or (4) three or more unsuccessful attempts at vaccination have been made, in which case insusceptibility is inferred. Instances of insusceptibility, however, are exceedingly rare, for out of 38,000 primary vaccinations, Dr. Cory only failed in one case, and in that one he had no opportunity of making a third attempt.

Certificates signed by a properly-qualified medical practitioner must be produced in proof of any of the exceptions enumerated, whilst a certificate of postponement must specify a period not exceeding two months, which may nevertheless be repeated by further certificates if necessary.

There is no doubt, however, that numerous cases are lost sight of by the vaccination officers owing to the frequent migration of parents from one town or sub-registration district to another, and it is notorious that in Leicester, Keighley, and many other parts of the country, the Vaccination Acts have been openly set at defiance during recent years, as they were at Gloucester previous to the epidemic of 1896. It need hardly be said, too, that much of the discredit which has fallen upon vaccination as affording protection against small-pox is due to the fact that the operation is often very imperfectly performed. Indeed, it is a constant complaint on the part of the poor-law medical officers, who are the public vaccinators, that some of their medical brethren make it no secret that the operation, as they perform it, is so slight that it is practically painless, though quite as effectual as the method prescribed in the official instructions. Moreover, it is well known that the proportion of certified postponements of the operation are enormously in excess in private practice when compared with those deemed necessary in poor-law medical practice, although the infant population of the well-to-do and artisan classes are, as a rule, much healthier and much less exposed to debilitating causes than infants who, in the usual course, are vaccinated gratuitously.

All these influences serve to minimise, to an extent which cannot be adequately estimated, the protecting influence which would be afforded by vaccination if it were systematically and efficiently carried out amongst all classes, but it is sufficient to point out that there is always a considerable residuum of the population who still remain unvaccinated, and a far larger proportion who have been imperfectly vaccinated, while the great bulk of the population never resort to revaccination unless under the pressure of an epidemic of small-pox. For it cannot be too forcibly insisted upon that revaccination is absolutely essential to renew in all respects the immunity conferred by primary vaccination; and as an illustration of its beneficial results it may be mentioned that in Germany, where it was made compulsory after the epidemic of small-pox of 1870-74, there has been no serious outbreak since its enforcement. In this country, however, revaccination continues entirely optional, but persons over twelve years of age can be revaccinated gratuitously by the poor-law medical officers, and when there is immediate danger of small-pox the age limit is reduced to ten. The medical profession, nurses, and sanitary officials face small-pox without dread or misgiving, just because they have the assurance that they are efficiently protected by revaccination.

Primary vaccination may be carried on from arm-to-arm for an indefinite and probably unlimited time, though the question has often been raised whether in successive transmission the vaccine virus may not become too attenuated to afford the protection originally attached to it. Results, however, do not confirm this view. The lymph should always be taken on the eighth day from healthy children, and from normal and unbroken vesicles, each of which, on the average, will supply lymph sufficient for five cases. No lymph should be collected from vesicles resulting from revaccination, nor from vesicles showing any signs of inflammatory action. Arm-to-arm vaccination undoubtedly yields the best results, and affords a guarantee to parents as regards the healthiness of the source of lymph, but the

lymph may be sealed in capillary tubes or dried upon ivory points, and retains its efficacy for a considerable time. Owing to imperfect storage and insufficient care as to the quality of the lymph, the lymph examiner appointed by the Local Government Board is obliged to reject a very large amount of the stored lymph which is forwarded to him by public vaccinators; and if this is the case with men who devote special attention to vaccination, it need hardly be said that the lymph stored by private medical practitioners is often of inferior quality, and sometimes may be altogether inert. As regards the operation itself, the instructions of the Local Government Board (see Appendix) enjoin that insertions should be made sufficient to produce at least four separate good-sized vesicles, or groups of vesicles, not less than $\frac{1}{2}$ inch from each other, the total area of which on the eighth day afterwards should not be less than $\frac{1}{2}$ square inch. No person, unless he has previously had small-pox, is unsusceptible to small-pox, and vaccination is protective against itself.

Calf-vaccination has of late years come largely into use, partly because it was believed that arm-to-arm vaccine was losing its protective power, but mainly on account of the fears of the possible transmission of syphilis or some other malady by vaccinating from human subjects. It is probable, however, that in the forthcoming Vaccination Act compulsory vaccination will solely be carried on by calf lymph, because this is one of the strongest points insisted on in the Report of the Royal Commission on Vaccination. Another section of the Report refers to Dr. Copeman's experiments on the effect of the storage of vaccine lymph in glycerine, which he announced to the International Congress of Hygiene in London in 1891. To quote from the Report: "The conclusions at which he arrives are that the addition of glycerine, whilst it leaves the efficacy of the lymph undiminished, or even increases it, tends to destroy other organisms," and the Commissioners also added that further investigation was desirable. In consequence of this recommendation Sir Richard Thorne and Dr. Copeman were instructed by the

Local Government Board to visit certain cities on the Continent, where vaccination with calf lymph has become the habitual, if not the universal, practice. They found that though calf-to-arm vaccinations were still carried on in Paris, in Germany this method had been as completely abandoned as the system from arm to arm,—(1) because Dr. Copeman's experiments had been confirmed by competent bacteriologists, to the effect that by the admixture to calf lymph of a 50 per cent solution of pure lymph in sterile water, and by subsequent storage of the lymph material in tubes, under due precautions, for several weeks, the preparation remained quite active as vaccine, whilst a very remarkable germicidal effect was produced on extraneous micro-organisms in the lymph; and (2) because by this method the amount of vaccine from a single calf can be enormously increased. At the Local Government Board's vaccine establishment, the lymph from one calf has hitherto been limited to 200-300 vaccinations, but at Berlin, lymph was prepared in the presence of Sir Richard Thorne by this system, which, it was asserted, would suffice for 15,000. Generally, however, the amount of glycerinated lymph obtained from a calf is limited to 4000-6000 vaccinations. The lymph is collected on the sixth day after inoculation of the calf, and though there are differences in the mode of preparation, the one most practised is to remove the pulp of the vesicles by scraping or scooping, then saturate or mix with glycerine and water, and store in small bottles with every antiseptic precaution. As the outcome of this detailed inquiry, and the results of experiments with glycerinated lymph prepared on the Continent, Sir Richard Thorne felt warranted in submitting the following amongst other conclusions :—" It is desirable that vaccination, both primary and secondary, carried out under the auspices of the Government, should be performed exclusively with vaccine lymph obtained from the calf" (see *Supplement to the Report of the Medical Officer of the Local Government Board for* 1896-97).

Primary vaccination in the human subject, whether from

arm to arm, or by calf lymph, is followed on the third day by a papule which on the fifth or sixth day becomes vesicular. The vesicle reaches maturity on the eighth day, when it is found to be of a greyish colour, tense, elevated, and loculated, and at this stage it contains a clear viscid lymph, which exudes when the vesicle is pricked. On the ninth day inflammatory changes set in, which are often accompanied by slight constitutional symptoms. A reddish areola will now be observed to surround the vesicle, which becomes pustular. On the tenth day the vesicle begins to dry up, and about the fourteenth day forms a dark scab, which falls off during the fourth week, and leaves a scar which should remain depressed and pitted.

On revaccination, if the persons have again become fully susceptible, the local effects appear earlier than after primary vaccination, and the local and constitutional symptoms are generally more severe. As regards unprotected persons, it is very important to remember that successful primary vaccination within three days after exposure to the infection of small-pox will prevent the development of the disease, and it is probable that the attack will either be arrested or modified by revaccination as late as the fifth or sixth day. This is rendered possible in the first instance by the shorter period of incubation of vaccinia as compared with that of small-pox, and in the second instance, by the still shorter period which generally follows revaccination.

Vaccine lymph, like small-pox lymph, contains micrococci, which are often seen in chains, and also bacilli which Dr. Copeman believes to be specific, but which so far have not been found capable of cultivation. Filtration through porcelain renders the lymph inert.

The readiness of parents to attribute to vaccination every disease, and especially any cutaneous eruption from which the child may afterwards suffer, has enormously magnified the alleged dangers attaching to the operation. It is quite possible that vaccination, like teething or any other irritating cause, may hasten the evolution of a constitutional disturbance or eruption which was incu-

bating in the child at the time, but this is by no means a common occurrence. Sometimes a roseolous rash, which may be vesicular or papular, appears on the vaccinated limb and spreads to other parts of the body. Then, again, erysipelas and diphtheria have both been known to be set up at the seat of vaccination, but such an occurrence is purely accidental, and is no more attributable to vaccination than it would be if it followed any other abrasion or puncture of the skin. The remote possibility, however, of such an occurrence suggests the advisability of not selecting rooms, which are used for purposes of medical relief, for vaccination stations. When the vaccinal vesicle leads to ulceration, it is due to the entrance of pyogenic microbes, and is attributable to the dirty habits of parents, uncleanliness of skin or clothing, or the insanitary conditions of the home. Sometimes erysipelas or ulceration may unfortunately be induced by inattention on the part of the operator to the most scrupulous observance of all proper precautions, such as—brightness and cleanliness of the lancet used, and careful cleansing after each separate operation; particular care not to draw any blood, and not to use the lymph of any vesicle from which blood may have been drawn; and, above all, not to abstract lymph from any vesicle round which there is an areola, because in this case there is great risk of the lymph being tainted with the common products of inflammation.

But the great danger which, as often alleged, attaches to the operation is the risk of imparting syphilis, but with ordinary precautions this should never occur, and the cases recorded have been remarkably few. Gangrenous ulceration has been noted in three cases, and was believed to be syphilitic until the cases were examined by Mr. Jonathan Hutchinson. (See *Archives of Surgery*, October 1889.) It is true that syphilis is by no means a very rare disease, but in inherited syphilis there is no chancre, nor typical development, after vaccination; the disease is wholly independent of the vaccination at the time; and there are the characteristic signs of the disease itself, such as the

radiating cracks around the mouth and nostrils, and the mucous patches around the arms and genital organs. In vaccination syphilis, on the other hand, according to Professor Fournier, the disease commences with local affection, chancre, and indolent bubo, while the general phenomena never appear earlier than the ninth or tenth week after vaccination.

2. *Measles* or *Rubeola* is more especially a disease of early childhood, and is highly infectious. The contagium may be conveyed by *fomites*, or by means of the contaminated air of the sick-room, and readily clings to surfaces. The period of incubation is from ten to twelve days, rarely a day or two more. The eruption appears on the fourth day after the febrile and catarrhal symptoms set in, and consists of a deep red-spotted rash, appearing first on the face and forehead, and afterwards on the trunk and extremities. The rash is at first slightly raised, and is distributed in crescentic groups, which extend over all parts of the surface. It persists as a general mottling after subsidence of the fever, and in severe cases may be followed by a fine desquamation. The constitutional symptoms seldom set in until eight days after exposure to infection, and generally consist of fever more or less intense, aching pains, and vomiting, followed by some signs of coryza, cough, and sneezing. The eruption lasts three or four days, and generally fades in the same local sequence as it appeared. In very mild cases there may be slight rash without catarrh, or catarrh without eruption. In the severe type of the disease, known as black measles, there is generally hæmorrhage from the mucous surfaces, and death may occur before the rash is thrown out.

The virus of measles is believed to be a specific microorganism, and Czajowski has recently maintained that he has demonstrated its presence in the blood.

The disease usually prevails as an epidemic, and it very rarely attacks a person more than once. When it breaks out in a school, or family, it is sure to spread—the catarrhal stage, which is infectious throughout, being often mistaken

for a cold, so that no precautionary measures are adopted. After an attack, personal infection is probably over by the end of the month, although it may persist longer. How long infection may cling to articles of clothing or linger in close rooms is uncertain. The average proportion of deaths to attacks in this country is from 10 to 12 per cent, and more than one-half the total number of deaths are of children under two years of age, while 90 per cent of the deaths occur among children under five years. Owing to the catarrhal nature of the disease, the fatality is increased by cold weather and on damp soils, and it has been suggested that of late years the disease itself has assumed a more virulent type. Occasionally measles, like small-pox, becomes pandemic, and diffuses itself for a brief period over large portions of the globe. Unlike scarlatina, measles often disappears entirely from a district in the interval between epidemics.

German measles, rötheln, or *rubella* is now recognised to be a distinct specific disease, and though one attack generally protects against subsequent attacks, it does not protect against an attack of rubeola or common measles. The period of incubation is longer than measles, mostly a fortnight. It is not so infectious as measles, nor are the symptoms so severe; but, like measles, it is a disease of childhood, though adults are liable to be attacked. The sudden appearance of the rash without any marked premonitory symptoms distinguishes it from measles. There may be slight coughing and sneezing, but within a few hours or a day after attention has been aroused, the rash on the face begins to make its appearance. The rash consists of discrete spots or blotches, from the size of a pin's head to that of a bean, round or oval, and of a pale rose-red colour, slightly raised above the skin, with a distinct, or at times, a faded border. After appearing on the face, these spots and blotches may also be seen on the neck and thighs, but less frequently on the forearms and lower parts of the leg. The size of the spots or blotches is less than those of measles, while their form is more round and their colour

paler. The eruption lasts two days, and then disappears without any desquamation. Infection persists for a month.

The precautionary measures indicated as regards common measles or German measles are isolation of the patient, careful attention to the hygiene of the sick-room, disinfection of clothing, bedding, etc., preventing children from infected households mixing with other children; and if outbreaks threaten to become severe the question will arise, especially in rural districts, whether closing of schools may not be deemed necessary.

3. *Scarlatina* or *Scarlet Fever* has been recognised in Europe for at least six centuries, and in this country it was first recognised as a distinct disease by Sydenham. It was long confounded with measles, and it is only during the last half century that it has been clearly differentiated from diphtheria. Although it often appears sporadically, it is, for the most part, an epidemic disease, and in many districts it rises and falls with great regularity, the usual intervals between the epidemic waves being five or six years. Of late years it has greatly diminished in degree of intensity and prevalence, due, no doubt, to improved sanitary conditions. In this country the minimum mortality is in March and April, and the maximum in October. Children under one year of age, and especially under three months, are comparatively rarely attacked, but the incidence rapidly increases, and reaches its maximum in the fifth year of age. Up to the tenth year, the mortality is higher amongst males than amongst females, but after that year the excess is on the female side, owing, probably, to the risks of home-life, and their greater exposure in nursing infected children. At all ages, however, the female sex is more liable to attack. About 45 per cent of the attacks occur at ages under five years, and 40 per cent between the ages of ten and fifteen years. There is no doubt that increasing age confers increasing immunity, and hence the double gain in shielding a child from infection during the first years of life.

During the last four or five years the etiology of scarlatina has been a subject of much contention. As

already pointed out in the chapter on Food, Klein maintains that the specific microbe of the disease is a micrococcus, which he has isolated and cultivated, and which, on inoculation into calves, produces a disease which he believes to be bovine scarlatina. Edington has also found a bacillus which he regards as the true specific microbe, cultivations of which, when injected into rabbits and guinea-pigs, produced an erythematous rash, followed by desquamation. But whether scarlatina can be classed as a bovine disease or not, all authorities are agreed that it is frequently conveyed through the agency of milk, and numerous disastrous milk outbreaks have been carefully investigated and recorded. (See page 74.)

The period of incubation is usually from three to four days; it may be only a few hours, and it may possibly extend to seven days. The longest clear interval from a single definite case has been four and a half days. The difficulty of determining the period of incubation in many cases is the fact that slight cases often escape attention, and that these are frequently the links in the chain of infection.

The invasion of scarlet fever is usually abrupt, the temperature beginning to rise at once and seldom preceded by rigors. The premonitory symptoms are slight languor, restlessness, vomiting often, and sore throat. The fever is characterised by suffusion of the eyes, flushing of the face, and difficulty in swallowing. The lymphatic glands at the angles of the jaw become enlarged and tender, and already the palate and tonsils are red and inflamed. Very often a fine flush of redness suffuses the neck and chest soon after the throat symptoms are complained of, and the eruption may thus be among the earliest signs of the disease. It generally appears by the second day, and is well marked on the third, or it may be delayed, suppressed, or recede. When well marked, the eruption begins on the neck, face, and chest, and soon spreads to the trunk and limbs. It is characterised by fine red points, closely spread over a large surface, leaving no clear skin between. They

are not raised above the widely-diffused flush, and momentarily disappear under pressure of the finger. The eruption reaches its fullest extension by the fourth day, and begins to fade on the fifth and sixth. Desquamation usually begins from the sixth to the ninth day, and, according to the severity of the attack, may take five to six, or even eight weeks in completion, the palms of the hands and soles of the feet being last to peel.

In the mild form of the disease, the symptoms may be so slight that they attract little or no notice, and it may be three, four, or five weeks before the shreddy look of hands or toes betrays the true nature of the illness. There may be sore throat with little or no rash, or well-marked rash with slight sore throat. It is these mild cases which often play such havoc in school outbreaks, especially in country districts. The first cases are often so slight that no medical attendant is called in, nor are any precautions taken, when suddenly severe cases crop up, all of them traceable to infection through school agency, and the school has to be closed.

In its severe type, the disease is sometimes designated as *scarlatina anginosa*, when the throat symptoms are the most dangerous; or *scarlatina maligna*, when the high fever and its consequences are marked from the first. Between these two types and the slighter forms of the disease there are all grades of severity, and the latter often proves rapidly fatal, before even the rash appears. In the former type the throat symptoms often present a diphtheritic appearance.

Although scarlet fever may attack persons of all ages, it specially attacks children between the third and fourth years; after the fifth year the chances of attack decline rapidly, and, as a rule, a previous attack confers permanent immunity from the disease. Taken generally, the proportion of deaths to attacks is about 10 per cent, but since the adoption of the Infectious Diseases Notification, the case mortality in many parts of the country does not exceed 2 to 3 per cent.

As regards the period of infection, there is no doubt that the disease is infectious so soon as throat symptoms set in, and before the eruption appears, but, according to my own experience, it is seldom that other cases break out in the same family if the first case is promptly removed to a hospital, and proper steps are taken to disinfect the house, etc. The patient ought not to be pronounced free from infection until desquamation has entirely ceased, and the whole surface of the body has been well bathed, nor so long as there are any signs of sore throat, any sores about the nostrils or ears, or any discharge from secondary abscesses. During the febrile stage, and when desquamation sets in, the contagium, like that of small-pox, is exceedingly powerful and volatile, so that no susceptible person can remain in the same room for any length of time, or even in the same house, unless the patient is carefully isolated, without running great risk of contracting the disease. Moreover, the contagium is contained in everything which proceeds from the patient, but more especially in the cuticular scales given off in desquamation. These scales, laden with the specific poison, are conveyed by the currents of air to every part of the room, and may settle on clothing, bedding, furniture, walls, etc. They preserve their virulence for an unknown period of time, and when disturbed are always liable to reproduce the disease. Thus, there are several instances recorded in which the fever has been contracted by sleeping in a room which weeks previously had been occupied by a scarlet-fever patient; and the fact that the poison adheres to articles of clothing is proved by instances in which the disease has been propagated by the clothing of pupils returning home from school, clothing sent home from infected laundries, or clothing received from infected houses where tailoring or sempstress work is done. Further, it has long been surmised that pet animals may be the media of conveying infection in outbreaks of scarlatina, even though they themselves may not present any throat or other symptoms.

The precautionary measures which are indicated by the

above remarks are obvious. Prompt removal to hospital, where hospital accommodation has been provided, is of the first importance, and when that is not possible, isolation of the case as far as the circumstances of the home will permit. But even in homes where no difficulty should be experienced, the necessary isolation and disinfection are too often grossly neglected, either because they are irksome, or, if the case is slight, because they are considered to be needless. With regard to special precautions, see next chapter.

4. *Diphtheria.*—This disease was not recognised under its present name in this country till about the year 1859, though there is no doubt that under various names it has prevailed in many countries, from the earliest times, as croup. It was first accurately investigated by M. Bretonneau about the year 1826. Although the etiology of the disease still continues to afford ample room for research, there can be little doubt that in its origin and spread it is often intimately associated with sanitary defects. It is more or less endemic in certain localities, and frequently prevails as an epidemic. (See Chap. XII.) Although it is not hereditary, there is no doubt that certain individuals and families evince a great susceptibility when exposed to infection, or to causes which are likely to produce the disease.

As regards age and sex, the mortality is greater among females than among males at all ages. In both sexes the mortality increases from infancy to a maximum in the fourth year of life, and declines steadily afterwards. Of the whole number of deaths attributed to diphtheria, 53 per cent occur at ages under five years, and 82 per cent under ten years.

As already stated, the Klebs-Löffler bacillus (see *ante*, p. 433) only develops at the point of infection and does not invade the blood or internal organs. It is maintained by bacteriologists that it can be so readily recognised that its presence is absolutely diagnostic of the disease, and indeed is now made a condition of correct diagnosis; but if so, there appears to be some confusion involved in the form of the disease designated post-scarlatinal diphtheria, which now so frequently finds a place in hospital returns.

The more extended researches of Klein in respect to the intimate connection of milk-supplies with outbreaks of the disease have already been summarised in Chapter II. (see pp. 77-82), and there is also presumptive evidence that chickens, pigeons, rabbits, cats, and dogs may suffer from diphtheria and communicate it to human beings. (See *Local Government Report*, 1888.)

The seasonal curve of diphtheria prevalence shows a relation to cold, the maximum mortality being reached in November and December, and the minimum in summer. The disease occurs upon both high and low levels; but Thursfield, Kelly, and others have shown that it exhibits a greater average prevalence upon damp soils, and this view is confirmed by Thorne. (See *Diphtheria, its Natural History*, etc.) A special incidence of diphtheria in damp houses, and where the autumn leaves are falling, has often been noted. It is also intimately associated with other insanitary conditions, such as defects in house drainage; but the preponderance of opinion discards any connection with polluted water. It often occurs sporadically; and outbreaks in secluded positions have been attributed to transmission of infection by wind for long distances. Although this is possible, it is highly improbable; otherwise the disease would assume much wider extensions than have been proved to exist. Up till quite recently it was far more prevalent in rural than in urban districts; but the vital statistics of the past few years show that the mortality rate has become higher among urban populations.

Diphtheria is specially characterised by the exudation of a tough false membrane on the soft palate, tonsils, pharynx, larynx, or trachea. This membrane, which is generally of a greyish white colour, may appear on any one or all of these parts, or it may appear in the vulva, vagina, or anus, or on a wound or ulcer. In the vast majority of cases, however, it is found on the mucous surfaces of the throat or air-passages, and generally commences on the tonsils. From thence it may spread in different directions, backwards and upwards into the posterior nares, or down-

wards into the larynx and trachea. The submaxillary glands usually become enlarged, and owing to the extension of the disease, difficulty in swallowing and breathing are common symptoms. There is generally great prostration of strength from the first, and in very severe cases the poison sometimes kills before any local symptoms are manifested.

With regard to the period of incubation there is great diversity of opinion, but there are good grounds for believing that in the great majority of cases it does not exceed a few days, probably not more than three. The invasion of the disease is generally occult and insidious. Three or four days may be passed without any characteristic signs being observable, when suddenly the disease explodes with an attack of stridulous breathing, and on examining the throat the characteristic exudation is then seen. It is often exceedingly difficult to diagnose between diphtheria, ulcerated sore throat, croup, and some types of scarlatina, unless absolute reliance is placed upon the presence of the Klebs-Löffler bacillus. Indeed, in outbreaks of diphtheria, cases presenting the characteristic features of all these diseases are to be met with,—slight ulcerated sore throat, large and inflamed tonsils with patches into the pharynx and croupous extension into the lungs, and skin eruptions suggestive of scarlatina.

It is always safe to regard a patchy throat accompanied by prostration and no symptoms of scarlatina, if not diphtheritic, as certainly infectious. Moreover, these patchy or ulcerated throats are so frequently met with as harbingers of outbreaks of diphtheria that Sir Richard Thorne has rightly regarded them as proving his theory of "the progressive development of the property of infectiveness," though he insists upon the diphtheria bacillus as the *causa causans* of the disease, the various types being a question of dosage, condition of throat, and environment (see Chapter XII.)

Among the sequelæ of the disease there is generally albuminuria as in scarlatina, and paralysis of various parts, more particularly of the soft palate, which often comes on after apparently complete recovery, or during the course of

the acute malady. A striking feature in this form of paralysis is the changed character of the voice and its distinct nasality, a feature which is occasionally of great value in inquiring into outbreaks of diphtheria, when early cases may have been regarded as cases of ulcerated sore throat.

When once the disease becomes developed it is eminently infectious, the contagium being given off principally from the throat and breath, although there can be little doubt that it is also conveyed by the other excretions, and may thus become disseminated through the agency of sewers or closets. According to Dr. Parsons, Local Government Inspector, the prevalence of the disease in the later months of the year may be partly accounted for by the stirring up of the sediment in sewers by the autumn rains, the poison lying dormant until thus called into activity. In a household, and among children, it is often disseminated by kissing, and, indeed, the greatest care ought always to be taken not to bend over the patient, so as to inhale the breath. Further, there can be little doubt that the infection is most portable, and may be conveyed in articles of clothing and the like, while bedding, furniture, and even the walls and floors, may retain the virus tenaciously. Of all diseases, not even excepting scarlatina, this is the one most liable to be disseminated through the agency of schools, partly because the symptoms are sometimes so mild as not to prevent children from attending school, but chiefly because the disease is peculiarly liable to be spread by the breath, and may be disseminated by the throat after children are sent back to school apparently well. The greatest care ought therefore to be exercised not only in keeping children from infected houses from attending school, or mixing with others, but in not allowing those children who have been attacked to return to school until all symptoms of debility and relaxed condition of throat have disappeared. The other precautions to be taken are much the same as those recommended with regard to scarlatina. The prophylaxis of the antitoxin treatment has already been discussed, but even those who support it admit that it is of short duration.

Brief reference may here be made with regard to *Membranous croup*. There is considerable divergence of opinion concerning the definition or etiology of this disease, for while some writers regard croup as acute inflammation of the larynx or trachea, followed by exudation on the inflamed surfaces, the majority of writers, following the French school, regard it as diphtheria. These hold that membranous exudation is never a result of simple acute inflammation, and this, so far as causation and sanitary precautions are concerned, is no doubt the proper view to take. So-called croup with exudation should therefore be regarded as diphtheria, and this view is strongly advocated by Sir Richard Thorne.

5. *Whooping-cough* or *Pertussis*.—This is an infectious specific disease, characterised by a peculiar spasmodic cough, of about six or eight weeks' duration, and chiefly affecting children and young infants. Indeed three-fourths of all the deaths attributable to it occur among children under four years of age, and by far the greatest mortality occurs in the first year of life. Over 90 per cent of the deaths at all ages occur during the first five years of life. The case mortality, although it varies with age, is about 2·5 per cent.

The period of incubation varies from four to fourteen days, the average being about a week. Usually some catarrhal or febrile symptoms, with or without cough, appear from the fourth to the seventh day after exposure. This stage lasts a week, and the whoop mostly begins about ten days after the ingress of the disease; but there is great irregularity both in the stages and in the severity of the symptoms. The cough is paroxysmal and very characteristic, the inspiration being attended by a peculiar crowing sound. Three weeks may elapse before children exposed to infection manifest the whoop, and they should therefore not be allowed to mix with others who are susceptible until this period is safely over. The disease is highly infectious from person to person, and the contagium is believed to be occasionally conveyed by *fomites* and by the clothes of those in attendance on the sick or who may visit them. The specific microbe has not been isolated, nor is the disease known to

be inoculable. Active infection, however, is given off by patients only slightly affected, or who are only in the early stage of the disease, and continued till some time after the characteristic symptoms have disappeared. The disease is largely spread by "neighbouring" and by school agency, and, as in the case of measles, by an utter disregard of any proper precaution in the way of isolation or the like. Indeed the prevalence of these two diseases is in great measure attributable to the culpable neglect, arising from the popular belief, amounting almost to fatalism, that children must contract them some time, and that there is therefore little use in endeavouring to take any protective steps when either disease is epidemic. The consequence is that the epidemic continues to spread so long as susceptible victims are to be found in the community, and only dies out for a time when almost all these have been attacked.

6. *Fevers.*—Fevers may be conveniently considered as they are classified in the returns of the Local Government Board, as follows:—Typhus, enteric and doubtful forms of fever; and continued, relapsing, and puerperal, fevers.

(1) *Typhus Fever.*—This fever has prevailed since the earliest times, and has been variously known as putrid, pestilential, ship, or jail, fever. It is an infectious febrile disease, marked by a peculiar dark mulberry-looking rash, accompanied by considerable cerebral depression, and usually lasts three weeks. It is eminently a disease of the poor, and is intimately associated with destitution and overcrowding. Except in the rookeries of our large towns, it is now a disease of comparatively rare occurrence, and cases are seldom met with in rural or small urban districts. No pathogenic microbe has been discovered.

The period of incubation has not been accurately determined, but on the average it is probably about twelve days, though Murchison maintained that it may vary from a few hours to three or even four weeks. The disease is ushered in by languor, dulness of all the senses, and fever. The mottled dusky eruption, especially noticeable over the abdomen, generally makes its appearance during the latter

half of the first week. During the second week the symptoms increase rapidly in intensity until the fourteenth day, when the disease appears to have attained its height. With the third week the general symptoms begin to improve, the rash quickly disappears, and by the end of the week the attack may be said to have terminated. The mortality is about 20 per cent, but varies greatly in different epidemics. Second attacks are rare.

Although not so infectious as small-pox or scarlatina, the disease is undoubtedly contagious, the contagium being thrown off by the cutaneous and respiratory exhalations. But the contagium does not travel far through the air, and it appears that if a patient can be isolated in a large well-ventilated room, there need be no difficulty in preventing the disease from spreading in the household. But as typhus is liable to break out in dirty and overcrowded localities, such isolation can only be secured by prompt removal to a hospital.

(2) *Enteric or Typhoid Fever.*—This has been defined as a continued fever of long duration, usually attended with diarrhœa, and characterised by peculiar intestinal lesions, a scattered eruption of small rose-coloured spots, and enlargement of the spleen. As pointed out in Chapter I., it was not recognised as a special disease until about the years 1848-50.

During the last few years, the literature of the bacteriology of typhoid fever has become voluminous, and the results are still very conflicting. Eberth, Klein, Koch, Gaffky, Rodet, and other bacteriologists, have all devoted special attention to the isolation and cultivation of what is generally accepted as the specific microbe of the disease, namely, Eberth's bacillus, but their experimental inoculation of animals, or feeding them on typhoid stools, cannot be regarded as altogether conclusive. But though it is maintained that there can be no typhoid without the bacillus, there is no evidence, on the other hand, that the bacillus must have passed through the intestine of a human being before it becomes specific. As already pointed out in

Chapter XII., it is capable of a separate existence in filth-polluted soils, which accounts for the endemic prevalence of the disease in certain localities, and serves to explain the impossibility of always being able to trace sporadic cases to previous cases, as well as the mysterious isolated outbreaks which sometimes occur.

But however conflicting the views as to its microbial origin or relations, it is generally admitted that enteric fever is essentially a filth-disease alike by those who assert its specific origin, and by those who, like the late Dr. Murchison and Sir William Jenner, maintain that it may be generated independently of previous cases. As it occurs in rural and small urban districts, my own experience leads me to believe that the great majority of scattered cases, and many of the first cases of isolated outbreaks, are due to poisoning of air, drinking-water, or other ingesta with decomposing filth. Most frequently it is found that the well-water has become polluted by soakage from some drain, cess-pit, or manure-heap, and in some instances it would appear as if ill-defined forms of fever, such as those vaguely termed low fever, gastric fever, febricula, and the like, may also be caused by decomposing organic matter. But whether the disease is produced by befouled air or polluted water, there is a constantly accumulating amount of evidence which goes to prove that neither the air nor the water need be tainted with the specific contagium of the disease traceable to a previously existing case. At the same time, there is no fact more clearly established in preventive medicine than this,—that whenever or however the disease is developed, the bowel discharges possess an infective power, which, where local conditions assist, can operate with terrible force, and often at long distances from the sick. It is rarely transmitted from person to person, but in crowded dwellings there is no doubt that there is great risk of its spreading if the evacuations and soiled clothing and bedding are not carefully disinfected, and strict cleanliness attended to. In country districts it is frequently propagated by throwing the excreta into common privies or ash-pit middens, and

in sewered towns it is generally spread through neglect to disinfect the excreta before throwing them down the closet, and thereby specifically polluting the sewer air.

Any epidemic of enteric fever in a sewered town points to imperfect ventilation, deficient flushing, or to faulty construction of sewers or drains (see Chapter III.), or to contamination of the water-supply, as in the outbreaks described in Chapter IX., or to polluted milk, as in the outbreaks referred to in Chapter II. In villages and country districts it points to polluted wells, bad drainage, or filthy privies and cess-pools, all of which may originate the disease in the first instance, as well as be the means of propagating the specific contagium when it is developed or introduced. Its relation to the air in soils and Pettenkofer's views have already been discussed in Chapter XII. Scattered outbreaks of the disease in this country, as well as in France and America, have been traced to the eating of oysters or other shell-fish from specifically-polluted oyster-beds, and the risks in respect to the condition of these beds are fully set forth in Dr. Bulstrode's Report to the Local Government Board, 1895.

The period of incubation is not definitely known, but in the majority of cases it is probably about twelve days, though in some instances which have been recorded the disease has set in immediately after exposure to intensely foul emanations from sewers or cess-pools which have been opened. But the invasion is almost always insidious, and the initial symptoms vague, and hence the stress laid on serum-diagnosis which has already been discussed (see *ante*, p. 424). The temperature, however, generally affords very conclusive evidence of the disease if it is carefully watched. It rises progressively from day to day, and is usually a degree or two higher in the evening than in the morning. The bowels at first may be confined or relaxed, but towards the close of the first week there is generally more or less tenderness in the right iliac fossa, and the abdomen becomes more or less tumid. The characteristic spots may be detected sometimes as early as the fourth or fifth day of the

fever, but usually they do not appear until a week or more has elapsed, and in a considerable proportion of cases they are absent altogether. They are pinkish in colour, about the size of a pin's head, slightly raised and pointed, disappear on pressure, and reappear when the pressure is removed. They are usually few in number, distributed irregularly over the abdomen and chest, and appear in successive crops, the duration of individual spots lasting about four days. If the case is distinguished by diarrhœa, it is at this period that it becomes most troublesome. The motions have a most offensive odour, are copious, liquid, rather pale in colour, and have a "pea-soup" appearance. Later on, when ulceration of the intestines has set in, they may become bloody, but hæmorrhage only occurs in about 8 per cent of the cases. In typical cases there is enlargement of the spleen. The disease reaches its height at the end of the third week, and the tendency to recovery is usually indicated by lowering of the temperature and abatement of the other symptoms. Relapses, however, are common, and convalescence in all cases protracted.

The principal precautions to be taken have already been indicated, but special care should be taken to disinfect excreta and soiled linen.

Cases of fever, of an undefined type, are to be met with in all outbreaks of enteric fever, and as a rule the scattered cases which crop up in rural and small urban districts are cases of this description. Such cases are variously returned as low fever, fever, febricula, and gastric fever, and, like enteric fever, may spread through neglect to disinfect and properly dispose of the ejecta by burying them in a hole dug in the ground, whenever possible. As already stated, these isolated cases of fever are generally found to be associated with polluted well-water or filth nuisances, and may fairly be designated as cases of filth-fever.

(3) *Continued Fever* may be accepted as a general term, including the ill-defined forms of fever just referred to, and which cannot be classified under other fever headings.

(4) *Relapsing Fever.*—This is a continued infectious

fever without any special eruption, and characterised by a tendency to relapse at intervals of from five to seven days, and generally occurring as an epidemic. It is essentially a disease engendered by famine or scarcity of food, and during recent years has become very rare in this country.

As already pointed out, a microbe, known as the *spirillum Obermeyeri*, has been discovered in the blood, which Obermeyer, its discoverer, and other observers believe to be specific, and inoculation with blood containing these spirilla has been found to reproduce the disease in monkeys. During the intervals between attacks the spirilla disappear from the blood, and hitherto it has not been possible to cultivate them. No doubt the disease is highly infectious, and though the infection readily attaches itself to fomites, it does not appear to be capable of transport through the air except for very short distances. In the majority of cases there is enlargement of the liver and spleen, but the mortality as a rule does not exceed 5 per cent.

(5) *Puerperal Fever.*—Although this term is often used very loosely, it is ordinarily restricted to manifestations connected with the puerperal state more resembling those of pyæmia than a specific fever. In this fever also a microbe bearing a close resemblance to the erysipelas micro-organism has been discovered, but Winter and Döderlein have both shown that the healthy vagina and cervix uteri swarm with organisms pathogenic in appearance and behaviour, but it is only when the lochia are present that organisms were found which on cultivation and inoculation produced abscesses. There is no doubt, however, that the disease is very liable to be spread from patient to patient by medical practitioners and midwives, if the most scrupulous care is not given to clean hands and finger-nails. A midwife, after attending a case of puerperal fever, should be prohibited from attending a second case of parturition for at least three weeks, and both midwives and medical attendants should use a disinfectant solution for washing the hands, such as a corrosive sublimate solution of 1 to 1000, or of carbolic acid 5 per cent, before and after all midwifery cases. Antiseptic

precautions and improved sanitation have practically banished the disease from lying-in hospitals, but unclean hands and finger-nails, probably as much as insanitary surroundings, still contribute largely to the death-roll of puerperal women.

Formerly it was believed that scarlatina was intimately associated with the spread of the disease, but as cases have been more carefully investigated, such intimate relation between the two has not been confirmed.

7. *Diarrhœa and Dysentery.*—Although diarrhœa is a prominent symptom in several diseases, it frequently assumes such a wide degree of prevalence during the summer months, and among infants, that it is variously designated epidemic, choleraic, or infantile, diarrhœa. While the disease proves especially fatal among infants, it is probable that children only form a small proportion of those who are attacked, although they furnish nearly the whole of the deaths. In England and Wales the average annual death-rate is 0·8 per 1000, but under five years it reaches the high rate of 5·7 per 1000. During the ten years, 1871-80, 63 per cent of the deaths attributed to diarrhœa occurred among infants under one year of age, and 80 per cent among infants and children under two years. It was by far the most fatal of the zymotics, and caused a mortality of 25 per 1000 births.

It cannot be said that any specific microbe of epidemic diarrhœa has been discovered, but Tomkins (see *ante*, p. 97) found a much larger number of micro-organisms in the air of infected areas than elsewhere, and Klein has discovered various bacilli and micrococci in the alvine discharges, some of which, however, could be differentiated as characteristic of the disease. The late Dr. Ballard, in his exhaustive report, presented to the Local Government Board in 1889, formulated what he called "a provisional hypothesis" as a result of his extended inquiry, which may be briefly stated as follows:—That the essential cause of diarrhœa resides ordinarily in the superficial layer of the soil, where it is intimately associated with the life-processes

of some micro-organism not yet isolated; that the vital manifestations of such organism are dependent among other things on condition of season, and on the presence of dead organic matter which is its pabulum; that such organism is capable of getting abroad from its ordinary habitat the earth, and having become air-borne, obtains opportunity for fastening on non-living organic material, such as food, whether inside or outside the body, which serves as nidus or pabulum; and that from food, as from all the organic matter contained in certain soils, such micro-organism can manufacture a virulent chemical poison which in the human body is the material cause of epidemic diarrhœa.

As regards influence of subsoil and locality, Dr. Ballard pointed out that a high mortality occurs on loose soils, which are easily permeated by air and water, and especially when such soils are contaminated with animal organic matter, such as sites which consist largely of ground made up with town refuse, garden refuse, or in which there is much pollution by leakage from drains or cess-pools, or from accumulations of filth. On the other hand, excessive dryness or wetness of soil is unfavourable to the development of diarrhœa. Under ordinary conditions the prime influence is increased temperature, but this influence is not a direct influence, excepting so far as it also affects infant mortality from other causes. The real influence at work is the temperature of the subsoil, and from a large number of observations extending over a series of years, Dr. Ballard gave the following summary of his results:—

"(*a*) The summer rise of diarrhœal mortality does not commence until the mean temperature recorded by the 4-foot earth-thermometer has attained somewhere about 56° F., no matter what may have been the temperature previously attained by the atmosphere or recorded by the 1-foot earth-thermometer.

"(*b*) The maximum diarrhœal mortality of the year is usually attained in the week in which the temperature recorded by the 4-foot earth-thermometer attains its mean weekly maximum.

"(*c*) The decline of the diarrhœal mortality . . . coincides with the decline of the temperature recorded by the 4-foot earth-thermometer, which temperature declines much more slowly than the atmospheric temperature or than that recorded by the 1-foot earth-thermometer.

"(*d*) The influence of the atmospheric temperature and of the temperature of the more superficial layers of the earth . . . is little if at all apparent until the temperature of the 4-foot earth-thermometer has risen as stated above; then their influence is apparent, but it is a subsidiary one."

The other influences on which Dr. Ballard dilates are the following:—

(1) *Density of population.* Epidemic diarrhœa is entirely a disease of towns. In 1888 the diarrhœa death-rate in the twenty-three large towns of England and Wales was 0·60 per 1000, while in small urban and rural districts it was only 0·31 per 1000.

(2) *Density of buildings* upon area increases the tendency to diarrhœa mortality, irrespective of the density of population which usually, though not always, accompanies it.

(3) *Want of ventilation and light*, such as in narrow courts and streets, back-to-back houses, or in dingy and overcrowded dwellings.

(4) *Want of cleanliness, and foul air* from sewers, cesspools, filth-accumulations, and the like. Smoke and mere chemical effluvia seem to be inoperative.

(5) *Drinking-water* may cause outbreaks of diarrhœa, independently of season, but does not produce ordinary epidemics of summer diarrhœa.

(6) *Social position* has an indirect influence, inasmuch as the poorest classes are obliged to live in the most unhealthy surroundings, and by far the greatest incidence of the disease therefore falls upon them.

(7) *Food*, and especially milk (see Chapter II.), often undergoes putrefactive change, owing to exposure to filth-emanations, and is thus largely productive of diarrhœa, more particularly among the infantile population. The statistics collected by Dr. Hope, now Medical Officer of Health

for Liverpool, and forwarded to Dr. Ballard, showed that out of 463 deaths from diarrhœa among children under six months old, only 23 had been fed from the breast alone. Infants fed entirely on breast-milk were remarkably exempt from diarrhœa, those partially breast fed came next, while the highest mortality was found to prevail among infants who were artificially fed, and especially when fed by the bottle.

(8) *Maternal neglect*, whether arising from the employment of mothers away from home, or from ignorance or want of care in nursing, adds constantly to the death-roll from infantile diarrhœa, and this was more particularly observable in the greater mortality among illegitimate children.

Isolated outbreaks of diarrhœa have already been alluded to in connection with food, air, and water (see Chapters II. III. and IX.) which arise independently of meteorological conditions, and which do not come under the category of epidemic diarrhœa. Such outbreaks are often sudden and severe, and as suddenly disappear. Any inquiry into their causation should of course be based on a list of cases, with dates of illness and death, and would embrace inquiry into circumstances of residence and locality, drainage, water-supply, any common exposure to foul effluvia, or the food eaten. But in respect to epidemic diarrhœa, the health officer will find from mortality statistics and pauper sick-returns that the disease generally attacks special houses, groups of houses, or parts of a town, and the precautionary measures indicated are—the enforcement of greater cleanliness, thorough scavenging, flushing, and disinfection of sewers, and issuing leaflets with instructions as to the feeding of infants, boiling milk, storing food, and disinfection of the excreta. As in the case of enteric fever, diarrhœal discharges infect the air of sewers, and in country districts the air of privies, cess-pools, and ash-pit middens. School closets, if not properly constructed and kept properly scavenged, are very liable to spread the disease.

Choleraic diarrhœa, as it is sometimes called, is char-

acterised by the suddenness of its onset, and is often accompanied by vomiting. The stools are at first feculant, but speedily become watery and are of a yellowish brown or rice-water colour. The name is unfortunate, because cases of this description, if they prove suddenly fatal, are sometimes returned as cholera, and give rise to needless alarm.

Dysentery depends chiefly upon inflammation of the mucous membrane of the large intestine, and may be either epidemic or sporadic. The former is peculiar to tropical climates, and takes the place of epidemic diarrhœa in this country. The latter, however, is not restricted to any locality, and is generally the result of lodgment of fæcal matter in the lower bowel, which acts as a foreign body, giving rise to inflammation.

Having thus far considered in detail the seven principal zymotic diseases, as they are called, it will be convenient to discuss briefly the other communicable diseases referred to at the outset in numerical order, and without any attempt at classification.

Group II.—Cholera and other Zymotic Diseases

1. *Cholera.*—True Asiatic cholera is a specific disease, characterised by the suddenness of its onset, by violent purging and vomiting, cramps, rice-water stools, collapse, and a tendency to run a rapidly fatal course. The average incubatory period is from twelve to twenty-four hours, and rarely exceeds one week.

Koch's vibrio, or "comma bacillus," is now generally accepted as the specific micro-organism of the disease. Its relations to soil have already been discussed in Chapter XII. (see p. 357). Haffkine's prophylactic inoculation, it may be said, still continues *sub judice.*

Although the disease has prevailed in India for many centuries, it was not recognised in Europe before 1829. At irregular intervals it spreads in epidemic or pandemic extension over various parts of the world, and follows the line of traffic by land or water, so that the invasion of each

new country along the line of march is almost invariably traced to some point of communication with a country already attacked. In this country it has become epidemic on four occasions, viz. 1831-32, 1848-49, 1853-54, and 1865-66. Reference has already been made in Chapter IX. to the last two epidemics and their intimate connection with specifically-polluted water, while the views of Pettenkofer have also been referred to. Sir John Simon's views, which were so forcibly enunciated at the time, continue true still—"excrement-sodden earth, excrement-reeking air, excrement-tainted water, these are for us the causes of cholera"; and whatever its microbial relations may be, these causes may be accepted as summarising the etiology of the disease wherever it prevails. Like enteric fever, it may be spread through the agency of milk, and Dr. Simpson, when Health Officer for Calcutta, has recorded an outbreak of this description which has already been referred to. (See Chapter II. page 83.)

In the Report of the Medical Officer of the Local Government Board on Cholera in England in 1893, it is placed beyond question that the distribution of shell-fish from the specifically-polluted oyster-beds of Cleethorpes and Grimsby had been concerned in the diffusion of scattered cases of cholera over a somewhat wide area of England. Since 1866, however, cholera, though more than once brought to our shores—as during the European epidemics of 1871-74, 1884-87, and 1892-93—has never succeeded in again establishing itself, and this result is no doubt due to improved sanitation and greater security from sanitary defence generally. (For Regulations and Memorandum on Precautionary Measures issued by Local Government Board, see Appendix.)

2. *Yellow Fever* is essentially a tropical disease, and its endemic areas are the West Indies and certain parts of the American and West African coasts. In 1864 a few isolated cases occurred at Swansea among persons who had come into direct contact with infected vessels. It is pre-eminently a disease of towns, and singles out the most insanitary parts.

It follows almost exclusively the lines of maritime traffic, and is not carried far by land. It is certain that ships become infected, and baggage and other fomites may retain the infection with much tenacity, though attendance on the sick does not appear to expose to much risk. According to Professor Parkes, it is highly probable that the infection is conveyed by vomited or fæcal matters, so that its etiological relations are closely allied to those of enteric fever and cholera.

The incubation period is stated to vary from two to fourteen days. The attack is generally sudden and severe, and sets in with high fever and persistent vomiting. The urine becomes albuminous or scanty, jaundice follows, and the patient passes into the typhoid state. The mortality is high. Freire has discovered a microbe which he believes to be specific, and inoculation with an attenuated cultivation has been tried as a preventive. Sanarelli has recently claimed that he has elaborated a curative serum from the horse.

3. *Malaria.*—Malarial diseases include several varieties of fever, such as intermittent fever or ague, and remittent fevers. All of them exhibit a tendency to periodicity in their course of symptoms. They exhibit their maximum of prevalence in tropical and sub-tropical regions, but are endemic in many marshy districts in Southern Europe, and occasionally spread as far north as the Baltic. As has already been pointed out in Chapter XII., they bear an intimate relation with character of soil, and degree of temperature and moisture. Malarious soils almost always contain vegetable matter, and in such districts heavy rainfall after long heat and drought is generally followed by outbreaks of malarial disease. Whether the malarial virus is the same in all varieties of the disease is still an open question, but most authorities agree that the blood of patients teems with a parasite discovered by Laveran in 1880, and variously designated *bacillus malariæ* or *Plasmodium malariæ*, which may be regarded as pathogenic and probably saprophytic.

The malarial poison is readily transmitted by air, but it

appears to be arrested by belts of trees or broad expanses of water, and does not rise many feet from the ground. Outbreaks of malaria have occurred on board ship, and have been attributed in some instances to foul bilge water, and in others to the fact that the water-supply was of marshy origin.

Ague was formerly very widely prevalent in this country, especially in the Fen districts and Essex, but of late years cases have become very rare owing to the general adoption of subsoil drainage.

4. *Dengue* or *Dengé* is a peculiar exanthematous disease which has prevailed epidemically in Eastern Africa, India, the West Indies, Mexico, and the Southern States of America. It spreads mainly along the lines of traffic, and in its diffusive intensity bears a strong resemblance to epidemic influenza, sometimes attacking cattle and other animals. It is a highly febrile disease, and is generally attended by swelling of the small articulations and a diffuse erythematous or spotty eruption, followed by desquamation, but the mortality is comparatively slight.

There seems to be little reason to doubt that the disease is highly infectious. No specific microbe has as yet been discovered.

5. *Epidemic Meningitis*, or *Cerebro-spinal Fever*, has occasionally occurred in this country, but the great bulk of outbreaks recorded have occurred in France, and for the most part these have cropped up in barracks. The attack is sudden, and is marked by shivering, pain in the head, vomiting, rigidity of the muscles of the back of the neck, and extreme hyperæsthesia. On post-mortem examination, exudations of lymph or purulent deposits are found at the base of the brain and in the spinal canal.

Dr. Bruce Lowe, one of the Inspectors of the Local Government Board, has reported on an outbreak of anomalous illnesses in certain parts of Northamptonshire which began to crop up towards the close of 1890. The leading character of the malady in one locality was, on the whole, pneumonic, the meningeal symptoms being generally sub-

ordinate; but in another locality, although pneumonic illness was common, there was a marked prominence of symptoms pointing to cerebro-spinal meningitis. Dr. Bruce Lowe suggests the suspicion that a gipsy family imported the disease, and assisted in spreading the infection elsewhere. (See *Report to Local Government Board*, October 1891.) It may further be noted that in the Departmental Report for 1888-89 there is a detailed summary of recent occurrences of epidemic cerebro-spinal meningitis in the basin of the Mediterranean. According to Ferguson, a disease of the same nature was found to affect pigs and dogs when it has assumed prevalence in Ireland.

6. *Epidemic Pneumonia* has been more or less prevalent in England and various other parts of Europe during the last two centuries. Nearly all outbreaks occur in winter and spring, and, according to Hirsch, the greatest prevalence is observed at the seasons of most rapid and sudden changes of temperature. Although the disease occasionally occurs in epidemic form, in many instances the outbreaks are limited to single households or to institutions—such as schools, barracks, or prisons. Insanitary conditions, especially filth, overcrowding, and want of ventilation, act apparently as very powerful predisposing causes, in so much so that the disease is sometimes designated *filth-pneumonia*. It is also known as "croupous" or "fibrinous" pneumonia. The disease is very often limited to the upper lobes of the lungs, and is frequently accompanied by pleurisy and empyæma. Gastric symptoms, diarrhœa, and jaundice are common, and the prostration is frequently out of all proportion to the pneumonic invasion. The *pneumo-coccus* of Fränkel is believed to be the specific organism of the disease, but it is also admitted that it is found in the nose, mouth, and throat of healthy individuals.

The incubation period appears to be short, usually about five to seven days. The onset is sudden, and usually marked by rigors and severe constitutional symptoms sometimes resembling in their intensity those of typhus fever. The mortality varies considerably, while the liability to attack

and the average case mortality both increase greatly as age advances. In the well-known Middlesborough outbreak in 1888 investigated by Ballard, the case mortality was found to be 21 per cent. Out of a population of 97,000, 1633 persons were attacked, and 369 cases proved fatal. The peculiarity of the epidemic, as observed in Middlesborough, was its strong tendency to occur in groups of cases, with sequence of the attacks among members of the same group as in diseases recognised to be infective. It was clearly proved that insanitary conditions favoured the extension of the disease, and a suspicion, which could not be altogether set aside, attached to contamination of food. Cases were very numerous in the workhouse, where the drainage was found to be faulty.

Klein, who carefully investigated the bacteriology of the outbreak, failed to detect Fränkel's *pneumo-coccus* in the diseased tissues, but he discovered large numbers of short bacilli which he named *bacilli pneumoniæ*. These he cultivated and inoculated into mice, and produced a disease, the chief and constant lesion of which was pneumonia, while further inoculations from such mice imparted the same disease to other mice. He also found that a large proportion of mice fed on samples of bacon purchased in the district exhibited similar symptoms. In all the infected mice whether inoculated with the lung-juice of patients or cultivations of the bacilli, or fed on presumably infected bacon, these bacilli were found in the tissues and could be transferred to other mice. Ballard, therefore, claimed for the Middlesborough epidemic a place among the class of "acute specific fevers," and suggested by preference the name of "pneumonic fever." (See *Report to Local Government Board*, 1888.)

Epidemics of pneumonia often occur coincidently with outbreaks of other diseases, and notably enteric fever, while in the fatal outbreak of influenza in 1891 the disease assumed enormous prominence.

7. *Epidemic Influenza.*—The name of this disease is of Italian origin, and came into use two centuries ago, but

much confusion has arisen from the prevalent misapplication of the term to severe catarrhs, which are themselves generally more or less infectious. Many epidemics of true influenza have been recorded during the last two centuries, and during the present century as many as ten—the last occurring in 1847-48. But the interval between this and the epidemic of 1889-90-91 was so great that the disease was practically unknown to the great bulk of medical practitioners of the present day. This epidemic, however, not only developed a huge literature on the subject, but opened up a wide field for discussion as to its bacteriological relations. Bacteria in profusion have been found in the sputum and blood and lung-tissue, but none are agreed as to the characteristics of a true pathogenic microbe. This much, however, has been established by Dr. Parsons's most elaborate report, presented to the Local Government Board, that the disease is eminently infectious, and that though its progress and mode of extension are highly irregular, it is propagated mainly, perhaps entirely, by human intercourse. The belief that the poison of the disease may be wafted across continents, and that the atmosphere plays the principal part in its diffusion, is controverted by the fact that the progress of the 1889-90 epidemic was found to be contrary to the prevailing winds, and that it was independent of season or any particular kind of weather. Moreover, it has not been shown to have travelled faster than human beings could travel, nor has it occurred among persons placed under circumstances precluding its communication by human agency. Dr. Parsons also found " that as a general rule it has appeared in each country, first in the capital or the ports of entry, or the frontier towns in communication with countries previously invaded, and that the towns, as a rule, have been affected earlier than the country places." Further, its power of infectiveness has been pre-eminently displayed in the rapidity with which it spread in public services and establishments where large numbers were employed in enclosed places, and in institutions in which the inmates are brought much into association.

It had been noted in former outbursts of influenza that horses suffered from a similar disease at the same time as man, but in the 1889-90 epidemic Dr. Parsons has made it clear that horse-influenza, so far as it was prevalent, preceded the human disease. In both, however, he found a great similarity in the chief symptomatic features, for in both the period of incubation was short, and stated to be from two to four days; in both the invasion was sudden; in both the duration of the acute period was brief; in both there was an absence of marked catarrhal complications in the majority of cases; and in both the leading features of illness were shivering, aching pains, hard dry cough, fever, and great prostration. But though the features of the disease in the horse and in man showed this great resemblance, Dr. Parsons admits that it is possible they are distinct diseases.

The percentage of lung-complications in the 1891 epidemic was enormously high, and in many parts the disease was associated with epidemic pneumonia, which prevailed chiefly among adults who had reached, or had long passed, middle age. The Registrar-General has estimated that during the four years 1890-93, the aggregate loss from influenza in England and Wales amounted to 46,615 lives, and that the indirect effect of the malady in increasing the death-rate from lung and heart disease probably represented an inclusive number of 125,000 deaths.

The period of incubation is short, probably from one to three days, and the breath is believed to be infectious from the first. Various species of bacteria have been discovered in the bronchial sputum and pulmonary, but the minute bacilli first described by Pfeiffer in 1892 are regarded as the specific micro-organisms, and they disappear with the cessation of the disease. Influenza in this country is most prevalent during the winter and spring. The precautionary measures indicated are early isolation as far as possible and in a warm temperature.

8. *Mumps*, or *Cynanche Parotidea*, is an acute infectious disease which specially attacks the parotid and submaxillary

glands, and is often attended with a considerable amount of swelling and pain, as well as difficulty of opening the mouth and swallowing. The disease occurs in all parts of the world, in brief, but sometimes intense, epidemics, which, however, cause little or no mortality. In this country outbreaks usually occur in the winter or spring, and frequently in concurrence with epidemics of measles, and, less rarely, with scarlatina prevalence. It does not show any periodicity in its return, and may be absent from districts for years. The mortality is very slight.

Nothing is definitely known of its bacteriological relations, nor of its etiology, beyond its extreme infectiousness by the breath. The period of incubation is about a fortnight, but longer intervals have been recorded. It is therefore often very difficult to repress an outbreak occurring in schools, though, as a rule, three weeks may be considered as a sufficient time for the isolation of a patient, or for the quarantine of a person who has been exposed to the disease.

9. *Plague.*—The Bubonic plague has been unknown in Europe since 1841, but throughout the Middle Ages frequent epidemics occurred in this country and on the Continent, as well as in various parts of Asia and Africa. During more recent periods, its principal endemic foci have been Southern China, and the Euphrates and Indus Valleys, and it is always liable to spread by trade routes. The recent recrudescence of the disease in Canton, Hong Kong, and other parts of China, as well as its ravages in Bombay and Poona, not only show that it is intensely contagious, but that it specially attacks the poorest classes, who are ill-fed, and are crowded together in the midst of squalid surroundings. Cantly and others maintain that it is communicable from rats and other animals to man. Yersin and Kitasato have demonstrated an organism, known as the plague bacillus, which has also been detected in the dust and earth from the floors of infected houses. Pure cultures of this bacillus when inoculated into rats, mice, and guinea-pigs induce symptoms and pathological appearances similar to those in the human subject, and the bacilli are recoverable from

the blood and viscera of the inoculated animals. Haffkine and Yersin have tried prophylactic inoculations on man, but many still question their success.

The precautionary measures indicated are isolation of the sick by prompt removal from overcrowded houses, thorough disinfection, and improved sanitation.

10. *Leprosy.*—This disease is one of the oldest known of all diseases, and still prevails in many parts of the world, and in all climates—in Norway, Sweden, the Riviera, India, China, South Africa, the Sandwich Islands, and Mexico, but it is more prevalent in hot countries. In this country leprosy has been practically extirpated since the close of the seventeenth century, but from the tenth century onwards, frequent historical reference is made to the disease and leper hospitals.

Leprosy attacks persons of all ages, and in all probability is communicated by contagion. No definite telluric conditions have been discovered, and it is not transmitted by water or air. It is characterised by the presence of nodules under the skin or mucous membrane, when it is termed "tubercular," or by degeneration of the nerve-trunks by these neoplastic growths, when it is called "anæsthetic." Minute bacilli, somewhat resembling tubercle bacilli, first discovered by Hansen in 1874, are found in these neoplastic growths or nodules, which are believed to be specific. They are capable of cultivation, but are difficult of inoculation into animals. They are not found in the blood, but are believed to infect the system through the lymphatics. The incubation is very variable, extending over months or years. Hutchinson contends that the disease is associated with certain kinds of food, and particularly fish, but the fact that it prevails in many elevated regions does not support this view. Danielsson maintains that the disease is hereditary, but this view is also contested.

Preventive measures rest mainly on isolation, and the removal of the children of leper parents from their leprous surroundings.

11. *Erysipelas* is an infectious disease, the common

external sign of which is an inflammation of the integument, extending in some cases to the areolar tissue, and tending to spread. A characteristic microbe associated with the disease was discovered by Fehleisen, which has stood all the tests of specificity by cultivation, inoculation, and reproduction of the disease in rabbits.

The most usual means of infection is by a wound, but numerous cases occur which used to be designated idiopathic, in which no abrasion can be detected. The scattered cases of this description, which occur in rural districts, and all of which must now be notified where the Infectious Diseases (Notification) Act is in force, are mostly of a trivial nature, and certainly suggest that if the disease is due to a specific microbe, the so-called *streptococcus erysipelatosus* must be saprophytic. At one time erysipelas was a formidable disease in the surgical wards of hospitals, but the fact that improved sanitation has almost completely banished it, proves that the disease has intimate relations with the ordinary putrefactive changes which occur in animal organic matter.

12. *Pyæmia, Septicæmia,* etc. — Professor Ogston of Aberdeen, Garré, Fränkel, and others, have endeavoured to differentiate these several varieties of septicism by the appearances and the behaviour of the micro-organisms which abound in all of them, but the results are by no means conclusive. The so-called *streptococcus pyogenes* resembles closely the streptococcus of erysipelas, and the micro-organism associated with puerperal fever. Carbuncle, whitlow, and osteo-myelitis have been determined by Garré to be due to *staphylococcus pyogenes aureus.* Pyæmia, again, has been divided into two kinds, presumably based on its microbial relations. In one the symptoms are believed to be due to the absorption of toxins, which may be produced by nonpathogenic organisms, and which is variously designated septic-poisoning, blood-poisoning, or sapræmia. In the other form of pyæmia there are well-defined suppurating centres, as a suppurating knee-joint or open wound, from which a continuous supply of poisoning

material is kept up, and this is known as *septicæmia*, or the *micrococcus-poisoning* of Ogston. Unfortunately, however, for the strictly specific microbial origin of these septic diseases, Fränkel maintains that he has discovered the *streptococcus pyogenes* in the blood without giving rise to any symptoms.

The tangled microbiology of these septic diseases only serves to show that, given filth or filth infection, and septic microbes crop up in abundance; secure perfect cleanliness and wholesome conditions, and they are deprived of their power for morbific mischief.

Group III.—Diseases common to Man and Animals

In this group are included tuberculosis, anthrax, glanders, hydrophobia, tetanus, actinomycosis, and foot-and-mouth disease.

1. *Tuberculosis.*—Apart from phthisis, tuberculosis entails a heavy mortality among children in the form of "tabes mesenterica" and "tubercular meningitis," although it must be admitted that both terms are employed somewhat loosely in death-returns, to ensure reliable statistical data. The death-rate from tabes mesenterica during the decade 1881-90 was 0·28 per 1000 of the population in England and Wales. Phthisis, however, under its popular name of consumption, still ranks among the most fatal and widely-spread of all diseases. During the four decennial periods —1851-60, 1861-70, 1871-80, 1881-90—the average death-rate per 1000 was 2·7, 2·5, 2·1, and 1·72 respectively. The reduction in the death-rate exhibited by these figures is no doubt mainly attributable to improved sanitation and a higher standard of national health. For whatever views may be entertained regarding its microbial origin, it is, in large degree, a hereditary disease, and, as abundantly shown in Chapters III. and XII., its incidence is greatly influenced by overcrowding, by air impurities in industrial employments, and by dampness of soil and dwellings.

But the researches, more especially of Koch, have opened up new possibilities of infection, inasmuch as the special *bacillus tuberculosis*, which is found in all tubercular lesions in man, is also found in the organs and tissues of cattle whose flesh is used as food, or in the teats and udders of milk-cows, and also in cow-milk. The dangers of infection from eating tuberculous flesh or using tuberculous milk have, however, already been discussed in Chapter II. (see pages 63 and 71).

In this direction there is no doubt that bacteriological research has conferred very material advantages from a public health or preventive point of view, but the policy of prevention must still remain based on the old lines, namely, a wider recognition on the part of the public of the great danger attaching to hereditary influence, and, as summed up by Dr. Ransome in the Milroy Lectures for 1890, the adoption of general preventive measures on the following basis :—

(*a*) Free ventilation for all in-door or underground workers.

(*b*) Out-of-door exercise for boys and girls, as well as men and women, and for this purpose the provision, in towns, of parks and recreation grounds.

(*c*) In choosing the business or profession of those boys who have shown a tendency to phthisis, it should preferably be one in which there will be little office-work, and as much out-door work as possible.

(*d*) Great care with regard to food, especially tuberculous milk.

The hopes which at one time were so eagerly and widely entertained that tuberculosis might be arrested or cured by inoculation have not been realised by the results of Koch's treatment, and it may be safely predicted that neither prevention nor cure lies in this direction, but will continue to rest on hygienic lines. At the same time it must be admitted that Koch's researches have been of the greatest value in emphasising more forcibly than heretofore the infectious nature of phthisis, and every great advance

in our knowledge of the natural history of a disease furnishes a more exact estimate of the best methods for prevention.

A series of most valuable contributions by several eminent writers appears in the *Practitioner* for June 1898, in which the disease is fully discussed in respect to its etiological, bacteriological, preventive, and curative, aspects.

2. *Anthrax* affects cattle, horses, sheep, and goats to a considerable extent in some countries, and is associated with a specific microbe, the *bacillus anthracis*. It is transmitted to men engaged in slaughtering animals suffering from the disease, or employed in treating their hides or wool, as in *wool-sorters'* disease (see page 103). Amongst the former *malignant pustule* is developed, and in wool-sorters' disease the spores of the bacilli find entrance by the respiratory or alimentary tracts. The incubation period varies, ranging from two to twelve days, the premonitory symptoms of internal anthrax being weariness, chills, restlessness, and a tight feeling round the chest. After a time, the temperature rises, prostration becomes extreme, and in fatal cases death ensues from syncope, pneumonia, or diarrhœal exhaustion. The bacilli of anthrax are readily destroyed by heat or other disinfecting agencies, but the spores are found to be extremely resistant. Klein has shown by results of inoculation, a further difference between bacilli and spores—the former causing only a slight localised malady, the latter a severe constitutional illness which is generally fatal. Pasteur succeeded in protecting animals by inoculating with the attenuated virus, but it appears such protection is of short duration. The prevalence of the disease among animals and its characteristic symptoms, as well as the dangers attaching to the consumption of the flesh of animals suffering from anthrax, have already been discussed in Chapter II. (See pp. 36 and 63.)

3. *Glanders*, or *Farcy*.—Although this disease has been transmitted from man to man on rare occasions, the infection is usually from the horse. It is not by any means a common disease, and the mode of infection is by inoculation

of the nasal and respiratory passages. The incubation period ranges from three to eight days, and the mortality is high.

4. *Hydrophobia* is the name given to rabies occurring in the human subject, and is imparted to man by the bite of rabid dogs, or, more rarely, rabid cats, foxes, or wolves. The incubation period ranges from six weeks to two years. The bacteriology and prophylaxis of the disease, associated with Pasteur's name, have already been discussed (see *ante*, p. 425). To stamp out the disease, a universal muzzling order, for a sufficient length of time, and not partial applications of such order, is necessary, though local repressive measures have no doubt been attended with success.

5. *Tetanus* affects horses, which may impart it to man, although such instances are rare. Traumatic tetanus is always more or less associated with filth-inoculation of wounds, and is therefore preventable by strict attention to cleanliness and by adopting antiseptic precautions. A characteristic microbe has been identified and cultivated, and the disease can be produced in animals by inoculating with stable refuse. The antitoxin serum treatment has already been discussed (see *ante*, p. 432).

6. *Actinomycosis.*—This disease affects the jaws of cattle (see page 42), and is associated with a ray or fission-fungus. The disease is transmissible in cattle by inoculation, but is rarely communicated to man.

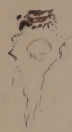
Group IV.—Parasitic Diseases

Although the majority of the diseases discussed in the previous groups may be classed as micro-parasitic on account of their intimate relations with micro-parasites, there are certain diseased conditions due to the invasion of parasitic animal organisms, which may be fitly noticed here.

1. The *Cestoda*, or *Tape-worms.*

(1) The *Tænia solium*, or tape-worm, infests the small intestine, and varies in length from two to ten feet or more.

It consists of a small head about the size of a pin's head, a neck about an inch long and unjointed, and a long segmented body. Under the microscope the head is seen to present four prominent suctorial discs, and between them a rounded elevation or *rostellum*, which is surrounded with about twenty-six hooklets of different sizes. The neck broadens out into the body, which consists of square or oblong flat segments named *proglottides*, each of which is provided with double sexual organs. Ova are produced in the segments, and escape with the excreta if the segments rupture or become detached, or if the whole worm is expelled. These eggs are spherical in shape, have a thick brownish shell, and are about $\frac{1}{700}$ inch in diameter, and when mature they may be seen to contain embryos furnished with hooklets.



As already explained in Chapter II. (see page 45), the ova, when swallowed by pigs, reach the intestinal tract, where the cell-cyst bursts. The embryo then escapes, and, attaching itself by its hooklets to the mucous surface, afterwards works its way into the tissues, and there becomes encysted as the *Cysticercus cellulosus* of measly pork. If the flesh containing these cysticerci is eaten by other animals in an uncooked state, the head or *scolex* reaches the alimentary canal of the new host, loses its cyst, and then develops, joint after joint, into the tape-worm. Man is very subject to tape-worms, and also, though much more rarely, to their cysticerci.

(2) The *Tænia mediocanellata* is perhaps as common as the *Tænia solium*, and somewhat resembles it, but the head has no rostellum or hooklets, though it is furnished with four suctorial discs. The *Cysticercus bovis* is smaller than the *Cysticercus cellulosus*, and occurs in the flesh of cattle. It consists of a cyst, and a scolex which is identical with the head of the tænia itself.

(3) The *Bothriocephalus latus* is the longest of all the tape-worms, and is principally met with in Sweden, Russia, and Poland. The head is ovoid or club-shaped, and provided with two longitudinal grooves or suckers, but no

hooklets. The embryo is ciliated, and found in river-water, and, according to Cobbold, the cysticercus is believed to have its habitat in fish.

(4) The *Tænia echinococcus* specially affects the dog or wolf. The head or scolex resembles that of the *Tænia solium*, but the worm itself is only about a quarter of an inch long, and has only four segments, the last of which is provided with sexual organs. The ova are spherical, and after being voided, find their way into the human body either in drinking-water, or on the leaves or stems of young vegetables. The cysticercus is a dangerous human parasite, under the name of hydatid, which affects the liver and various other parts of the body, such as the stomach, intestine, or lung. But the ova develop in other animals besides man, and especially in sheep, the echinococci of which are devoured in the offal by dogs which frequent slaughter-houses, and in them reproduce tape-worms. In Iceland, owing to the infection engendered by the huddling together of dogs and human beings in close dwellings, it is notorious that about one-seventh of the total mortality is due to hydatids.

There are other varieties of tape-worms, such as the *Tænia nana*, which is common in Egypt, Italy, and Sicily, and the *Tænia cucumerina*, but these do not require special notice.

2. *Nematoda*, or *Round-worms.*

(1) The *Ascaris lumbricoides* infests the small intestine in man and other animals, and it appears to be common in all climates. The head consists of three conical prominences, furnished with tactile papillæ and minute teeth. The male worm is about 6 inches long, and the female about 12, and in both the body tapers from before backwards. The ova are nearly round, brownish yellow in colour, and measure about $\frac{1}{450}$ of an inch in diameter. It is believed that the ova have their habitat in some intermediary host, and are conveyed into the human system through the agency of drinking-water.

(2) The *Oxyrius vermicularis*, or small thread-worm, infests the colon or rectum, and is generally met with in children who are poorly fed. The male worm is about a

quarter of an inch in length, and the female about half an inch. The natural history of the thread-worm has not been well established, but it is probable that it is frequently disseminated by drinking-water.

(3) The *Anchylostoma duodenale*, or *Dochmius duodenalis*, as it is sometimes called, is exceedingly prevalent in Egypt, and also in Germany, Switzerland, and Belgium. It produces a severe form of anæmia, especially among brick-burners, miners, and navvies who work in tunnels. The mouth of the worm is armed with four claw-like teeth, by which it attaches itself to the villi of the small intestine, and often leads to hæmorrhage.

(4) The *Tricocephalus dispar* is a whip-like worm, consisting of a thick, short hinder-part, and a long, spiral, filament-process, anteriorly. Its habitat is the cæcum. It is rarely seen in this country, but, according to some authorities, it produces, along with the *anchylostoma* and an insect larva, the disease known as beri-beri.

(5) The *Trichina spiralis* produces the well-known disease *Trichinosis*, which is far less common in this country than in Germany, where ham, pork, and sausages are often eaten raw, or in an imperfectly cooked state. The inspection of trichinous meat, as well as the microscopical appearances of the trichina, have already been discussed in Chapter II. (see page 44). When trichinous food, such as pork or ham, is eaten in an uncooked state, the capsules containing the trichinæ are dissolved by the gastric juice, and the liberated trichinæ develop rapidly, the male attaining a length of $\frac{1}{18}$ of an inch in two or three days, and the female about $\frac{1}{8}$ of an inch. Ova are then formed and impregnated in the female, and are hatched in about a week. So soon as the embryos escape they burrow into the walls of the intestine, and find their way into the tissues of all parts of the body, and especially the muscular tissue, where they again become encysted within about a month after the trichinous food has been ingested.

Trichinosis is common to several rodents and other animals, as well as man and pigs. In man the symptoms

commence within about a week with intestinal disturbance somewhat resembling that of typhoid fever. The tongue becomes coated, and this is generally accompanied by diarrhœa and great prostration. If fever is present, the symptoms are usually slight, but it is characterised from the first by an abnormal amount of perspiration. The malady continues in its acute stage for about one or two weeks, and then gradually subsides, but fatal peritonitis, enteritis, or pneumonia may supervene, or, in severe cases, the patient may die from exhaustion. In addition to the remarkable increase of perspiration, so-called "muscular lameness" sets in when the tissues are invaded. The muscles become painful, swollen, and stiff, as in rheumatism, except that the joints are not affected, while there is œdema of the face and eyelids, which may subsequently involve the hands and feet, and also the serous cavities. Owing to implication of the larynx, the voice often becomes hoarse or aphonic. The severity of the symptoms will vary greatly according as the food was highly infested or not when ingested, and, of course, will also greatly depend upon the degree of cooking. The mortality is sometimes slight, but in several outbreaks it has reached 20 or 25 per cent. When recovery takes place the trichinal cysts become coated with lime salts, and the encapsuled parasite dies.

Although the disease is not very often observed in this country, there is every reason to believe that many cases are not accurately diagnosed on account of the somewhat puzzling symptoms which they exhibit.

(6) The following animal parasites are noted indiscriminately :—

(*a*) The *Pentastoma constrictum* infests the liver and lungs. It measures half an inch to an inch in length, and is recognised by the presence of twenty-three rings. It is common in some parts of Africa, and sometimes attacks European residents in the West Indies.

(*b*) The *Filaria Sanguinis Hominis* is a hair-like parasite, which may attain a length of three or four inches, which, when it invades the urinary tract, produces chyluria, and

it is also associated with elephantiasis. The parasite in the immature form, as well as the ova, can be detected in the blood and urine. The ova are about $\frac{1}{1000}$ inch long, and the embryo is enclosed in a transparent tubular sac, which is extremely delicate and translucent. The parasite is found chiefly in the East and West Indies, but it has occasionally been met with among persons who have never left this country. Three varieties of the parasite have been described by Manson.

It is surmised that embryo *filariæ* in the blood are imbibed by the mosquito, which deposits its eggs in water along with the ova of the *filariæ*. It is supposed that the embryo passes its next stage of existence as a free nematode in water, but that it can only attain its full stage of sexual development in the human body, after obtaining entrance through the skin of bathers, or, very probably, in drinking-water.

(*c*) The *Filaria medinensis* or *Guinea-worm*, is endemic in tropical regions. The worm itself varies from one to three feet in length, and the embryos affect minute aquatic crustacea, and obtain entrance to the human body either through the skin while bathing, or by means of drinking-water.

(*d*) The *Bilharzia Hæmatobia* is a bisexual entozoon of the fluke type, the male being about half an inch long, and the female about three-quarters of an inch. It infests the branches of the portal system, and the minute veins of the kidney, ureter, and bladder. The symptoms vary according to the region attacked, but if the urinary system is invaded, there is generally blood in the urine, and shreds of mucus are passed which are found to contain the ova of the parasite.

It is believed to gain an entrance into the human body either by drinking-water, by eating infested salads, or by direct infection of the alimentary or urinary tracts while bathing.

Group V.—Communicable Diseases of the Skin

Certain *Parasitic and other Infectious Diseases of the Skin* often spread among school children, and may become very troublesome. Indeed, it should be made a rule among teachers that any child exhibiting an eruption on the face, head, or hands, should be prohibited from attending school until cured, and skin cleanliness should be enforced as strictly as possible at all times.

1. Ringworm (*Tinea tricophytina*) is a parasitic disease caused by a fungus. When it attacks the scalp it is known as *Tinea tonsurans,* and when it appears on the general surface of the body it is termed *Tinea circinnata.* Tinea tonsurans is rarely seen among adults, but often becomes a very troublesome complaint among school children. The disease is easily recognised by the irregular scaly patches which generally appear first on the top of the head. The hairs which grow on these parts are withered and dry, and most of them are broken irregularly. Under the microscope the fibrous structure of the hair, if first steeped in liquor potassæ, will be seen to be split up, and filled with chains of spores.

The disease is spread largely by the mixing of hats and caps at school, and there is no doubt, too, that it is often communicated by the combs and brushes used by the hairdresser.

2. *Tinea favosa,* or Honeycomb Ringworm, is also a very obstinate skin affection, due to the presence of a fungus, the *Achorion Schönleinii.* There is no doubt that the disease is infectious, and it generally attacks the scalp. It requires a congenial soil on which to spread widely, and it is therefore found most prevalent among the children of the very poor, and especially when they are dirty and ill-fed. Cleanliness and healthy surroundings banish the disease. In the early stages the patches are irritable and scaly, after which bright yellow crusts, small and distinctly cup-shaped, are formed, and eventually these crusts fall off. Owing to the irritation of the skin, scratching gives rise to numerous secondary

lesions, such as bleeding and suppuration. It is believed that the disease is sometimes spread by cats.

3. *Impetigo contagiosa.*—This is a contagious vesiculo-pustular eruption which attacks children in the vast majority of cases, and often spreads in the same family, or in schools. The small vesicles first make their appearance on the face, and though they sometimes appear on the hands, do not often spread to other parts of the body. The contents of the vesicles, some of which may be as large as lentils, become milky, then sero-purulent, and afterwards dry up into scabs, which, on falling off, leave a smooth surface. The eruption is composed of one or more crops, and, if neglected, may not disappear for six or seven weeks.

4. *Eczema.*—Unna's views with regard to the contagiousness of eczema have received the strongest confirmation in the prevalence of a fatal epidemic of this disease which broke out in the Paddington and Marylebone Workhouse Infirmaries in May 1891, and continued up to November. In both Institutions the total number of cases amounted to 356, and the deaths to 56. According to Dr. Savill, Superintendent of the Paddington Infirmary, there were two types of the disease observable, a dry type, and a moist type. The primary attack lasted from six to ten weeks, and relapses were common. This curious outbreak was almost exclusively confined to old patients (see *British Medical Journal*, 5th December 1891).

5. *Scabies* or *Itch* is caused by an animal parasite known as the *Acarus scabei*, which under the microscope very much resembles the cheese-mite. An adult specimen has eight legs, and the head is provided with strong movable mandibles. The eruption on the skin is caused by the burrowing of the acarus for the purpose of feeding and propagation, and is also increased by the scratching due to the irritation induced. It most frequently appears on the flexures of the joints, and generally is first observed between the fingers, and afterwards on the wrists and forearms. It is not so infectious as ringworm, and, as a rule, is only spread from person to person when they sleep in the same bed,

but cases have been known of its spreading among school children.

Concluding Remarks.—Having thus far considered in detail, but without any attempt at classification, all the more important communicable diseases, a few words may now be added concerning *channels of infection.* And first, it has to be pointed out that diseases, such as scarlatina, measles, and whooping-cough, which especially attack young children, are almost invariably spread through the agency of schools. Not only are children from infected houses allowed by their parents to attend school so long as they are not prohibited by public officials or the medical attendant, but it often happens that children who are only affected to a slight extent with one or other of these diseases are permitted to go to school as usual, and thus become certain and dangerous centres of infection. But apart from the disastrous results which depend upon the ignorance or reckless indifference of parents in this respect, there can be no doubt too that the agency of schools in the propagation of infectious diseases is becoming all the more potent as attendance becomes better enforced. It is often urged by teachers and school managers that it is no use closing schools to check the further spread of infectious disease, because the children are sure to mingle and play together out of doors. But the conditions are altogether different. In the open streets there is far more free space, and there is comparatively little risk of inhaling infection from the breath and clothes; whereas at schools the children's caps, bonnets, shawls, and overcoats are hung up together; the children themselves are packed so closely while in school that they must inhale each others' breaths, and have to run all the risks of personal contact; while the dangers are frequently increased by the condition of the outside offices, which in country districts especially are still sometimes of the foulest description, and notoriously neglected.

Among other channels by which infectious disease is frequently spread may be mentioned the occurrence of cases

in small shops, or other places of business. Under such circumstances, an attempt is generally made to conceal any cases of the kind as long as possible, because the shopkeeper is afraid of losing his business and frightening his customers. Then, too, there can be little doubt that infectious disease is often spread by tailors and sempstresses, who are allowed to stitch the garment of the fashionable wearer in their own miserable homes, where perhaps a sick child suffering from scarlet fever, measles, diphtheria, or whooping-cough lies covered with rags in a corner of the same room. Indeed, in London and other large towns, there is very little of the actual work of fashionable tailoring or millinery establishments done on the premises; the large bulk of it is taken home by the work-people and finished there. It is to be hoped that the enforcement of the Infectious Diseases (Notification) Act will greatly lessen risk in this direction, but there is no doubt that numerous cases of infectious disease will still not be reported, because medical assistance will not be solicited.

But there are other channels of infection which operate perhaps even more disastrously than these, and amongst them may be mentioned the following:—Pawnshops, where articles of clothing from all parts, and mostly from insanitary homes, are huddled and stored together; small laundries, which are scattered round the outskirts of towns; dairymen's premises, when they are not properly supervised and kept in order; and lodging-houses in fashionable health-resorts. People who live in clean and elegant houses, away from the foul breeding-places of infectious diseases, are too apt to forget how closely the dangers press upon themselves, for not only may their clothes be made in these pestiferous localities, but servants, charwomen—"the hewers of wood and drawers of water"—who attend to their wants, either live in the overcrowded slums of our large towns, or have friends or relations whom they visit there. It thus appears that infectious diseases take advantage of almost every relationship of life. The infective material may be left in a cab, communicated in a railway carriage, or be

actually inhaled from the breath or infected clothing of the person sitting next one in an omnibus or tramway car.

The wider channels of infection, such as water-supplies and public sewers, have already been fully illustrated, while recent inquiries go to prove that domesticated animals play a far greater part in the propagation of infectious diseases than has hitherto been suspected.

CHAPTER XVI

PREVENTION AND DISINFECTION

SECTION I.—PREVENTIVE MEASURES

ACCORDING to Sir John Simon's emphatic dictum already quoted in Chapter I., the causes of preventable disease may be grouped into two great classes, namely, local conditions of filth and nuisance polluting air and water, and reckless dissemination of contagion; and as regards both these wide fields of disease-causation, large powers have been conferred on Sanitary Authorities, and obligations expressly imposed on them by the legislature, to remove the former, and to see that means of isolation and other preventive measures are fully and fairly carried out to control the latter. Improvement of local circumstances, as embraced in all that appertains to sound sanitation, is therefore a most important—perhaps the most important—part of prevention. But though sound sanitation, both in respect to public and private hygiene, may be regarded as the first line of sanitary defence, there are other measures which are of special service in checking the spread of dangerous infectious disease—such as vaccination, means of isolation, disinfection, and compulsory notification. Vaccination, however, only applies to the control of small-pox, and as no such prophylactic method of prevention has been discovered as applicable to any of the other infectious diseases, we must mainly depend on isolation to protect an always more or less susceptible population. Apart, therefore, from efficient sanitary administration, local authorities cannot be

regarded as having discharged their duties to the public unless they have provided hospital accommodation and means for disinfection, either separately, or in conjunction with neighbouring authorities, and have also invested themselves with statutory powers to compel the notification of all cases of dangerous infectious disease occurring within their districts.

1. *Hospital Isolation.* — The kind and amount of hospital accommodation required to meet the wants of differently circumstanced sanitary districts, together with plans, have already been discussed in Chapter XIV., and though it may be true that the great majority of large urban Sanitary Authorities have already made provision in this direction, it is notorious that many of the hospitals were hurriedly erected under the pressure of an epidemic, generally of small-pox, and that the accommodation which they furnish is of an incomplete and temporary character. Moreover, in respect to rural and small urban districts throughout the country, it may be said that very little provision of any kind has been attempted; indeed, there can be no doubt that this question of hospital accommodation can only be satisfactorily and economically solved, so far as these districts are concerned, by conferring adequate powers on County Councils to purchase existing hospitals and erect new hospitals in localities best suited for the distribution of the surrounding population.

Although it is possible to isolate almost any case of dangerous infectious disease in a good-sized house, it is generally admitted that home-isolation in the dwellings of the artisan and labouring classes cannot be carried out, as a rule, without risk of spreading disease. Hospital isolation should, therefore, be urged whenever practicable for all cases which cannot be safely treated at their own homes, but unless under very exceptional circumstances no patient should ever be removed without the concurrence of the medical attendant, and it should always be remembered that removal can only be legally enforced under Section 124 of the Public Health Act, 1875.

As regards the special diseases for which isolation hospitals are deemed necessary, there is a general agreement that sufficient accommodation should be provided for cases of small-pox, scarlatina, and diphtheria. But in hospitals based on the plans issued by the Local Government Board, it is also possible, and always desirable, to be able to isolate cases of enteric fever. It is very doubtful, however, whether hospital isolation would be of any material assistance in checking the spread of either measles or whooping-cough, partly because these diseases are treated by the public with such utter unconcern, and because, as they attack very young children, there would be the greatest objection to removal on the part of parents. But for very urgent or exceptional cases there is no reason why the small wards of a hospital should not be made available.

2. *Public Provision for Disinfection.*—It has already been pointed out in Chapter XIV. that a disinfecting chamber with all proper appliances should form an adjunct to every hospital. But even in districts where no hospital accommodation has been provided, a disinfecting station, or, for rural districts, a movable apparatus would be of the greatest advantage in securing thorough disinfection of bedding, mattresses, and articles of clothing, and full power is given to all Sanitary Authorities to make such provision. They are also empowered to disinfect rooms free of charge, and to supply disinfectants liberally to all who cannot well afford to buy them. The powers and obligations of Sanitary Authorities in respect to isolation and disinfection, and the duties of Health Officers as regards prevention generally, will be more fitly discussed in Chapter XIX.

3. *Notification.*—As it is essential to prompt preventive action that early information should be obtained of the occurrence of every case of dangerous infectious disease, it is incumbent on all Sanitary Authorities to adopt the Infectious Diseases (Notification) Act of 1889 (see Chap. XIX.). Previous to the passing of the Act, compulsory notification had been in operation in several large towns under special Local Acts, but the Act of 1889 rendered notification

compulsory in London, and placed it within the reach of all other Sanitary Authorities throughout the country, whether urban or rural. Although the Act was thus to a large extent an adoptive Act, the advantages which it conferred were so manifest that it has been adopted by the vast majority of Sanitary Authorities, and it has recently been made compulsory in Scotland by Section 44 of the Public Health (Scotland) Act, 1897. Among the advantages which notification confers are the following :—

(1) Early information of all cases of notifiable disease, and therefore an accurate knowledge of disease prevalence and distribution in a district.

(2) Opportunity afforded of inquiring into the probable causes of infection, whether through direct infection, as in the household, or during a visit, or through school agency ; whether associated with any insanitary conditions of premises or quality of water-supply ; whether conveyed by milk or other articles of food, etc. It is only by the comparison of data afforded by inquiry into the particulars of each case notified, that outbreaks depending upon water-supplies, milk-supplies, infected schools, or other common origin, can be detected and checked.

(3) Power to secure prompt removal to hospital, if that is practicable, and to enforce the provisions of the Public Health Act and the Infectious Diseases (Prevention) Act with respect to isolation, quarantine, and disinfection.

Unfortunately the Infectious Diseases (Prevention) Act of 1890 is also an adoptive Act, but, as will be shown subsequently, it contains several very important clauses bearing on milk-infection and disinfection, and should therefore be adopted by all Sanitary Authorities.

4. *Quarantine.*—This term, which bears an old-world significance of isolation for a period of forty days, is variously applied in respect to modern preventive measures. In foreign countries it refers to the detention of persons on board ship or in camps, to prevent the invasion of cholera, or other dangerous infectious disease. If, for example, a ship arrives at a foreign port with cholera cases

on board, some Governments require that the whole of the crew and passengers, healthy as well as sick, shall be detained on board ship until such time as the vessel is declared free from infection. Or, if the disease has obtained a footing in the country, they may forthwith proceed to form *cordons sanitaires*, with a view of preventing people leaving the infected district. Or, again, if travellers from an infected district in another country cross the boundary of a neighbouring country, they may be subjected to all the annoyance of detention until the supposed period of incubation has passed; or if cases crop up amongst them, they may be detained for an indefinite period. At ports in the Mediterranean, all passengers on board suspected vessels used to be landed and isolated for from three to six days, while if the ship was infected, there were five days' detention.

That such a system of quarantine is as impotent as it is vexatious and inhuman has been proved again and again, inasmuch as quarantining countries are essentially the countries which cholera invades. For apart from the interference with commerce and the horrors of isolation camps which it entails, the system has a blighting effect on all sanitary progress in the countries in which it is enforced, just because reliance is placed solely on detention and *cordons sanitaires*, and not on improved sanitation, which alone constitutes the true basis of sanitary defence. This was the view which was so strongly advocated by Sir Richard Thorne in his official capacity as delegate from Great Britain at the Sanitary Congress held in Rome in 1885, and it has recently been strongly supported at the Dresden Conference which he attended to meet the delegates from other countries.

Quarantine on these rigid lines has long since been abandoned by this country, because reliance is based on sound sanitation, and the only other preventive measures required are inspection of vessels, removal of the sick to hospitals, and disinfection.

But quarantine in a less restricted sense is often of immense advantage in preventing the spread of infectious

disease. For example, in some towns, as in Leicester, quarantine stations are provided for the reception of persons from an infected house after removal of the patient to hospital, where they are maintained free of charge until the incubation period has passed; and in the meanwhile the house and its contents are thoroughly disinfected. Such stations are usually attached to the isolation hospitals, and the plan has been adopted more particularly as a protection against the spread of small-pox. But under the Infectious Diseases (Prevention) Act, Sanitary Authorities are compelled to provide, free of charge, temporary shelter for the members of any household who may be required to leave their dwelling while disinfection is being carried on. Although such provision is not ostensibly made for quarantining the household, it might, under exceptional circumstances, be readily utilised for that purpose.

In districts without isolation hospitals, it often becomes necessary to carry out a somewhat strict kind of quarantine in respect to an infected household. If, for instance, a child is suffering from a disease which the father is likely to disseminate, he should be kept from work, and be paid to stay at home and assist as a nurse. Indeed, under the heading of expenses for nursing, a Sanitary Authority may not only pay for a nurse, but also pay for a messenger to carry food and other articles to the house, if it be deemed necessary to quarantine the whole household during the illness. Liberal payment to the bread-winner under these circumstances is always desirable, because it enables the sanitary officials to carry out protective measures which they would have considerable difficulty in legally enforcing, and if the cost is sometimes considerable, it is but poor compensation for hardships which would otherwise be avoided if hospital accommodation were always available. Then, again, in rural districts it is sometimes possible to stamp out an outbreak by hiring an infected house, if it should happen to be large enough, for purposes of isolation, and removing any other cases which may crop up to this temporary hospital. On more than one occasion I have

advised such a course to be pursued, and with the best results, while the cost entailed was comparatively trifling.

After a patient has been removed to hospital, and the sick-room and its contents have been disinfected, it is only necessary to keep the household under observation during the maximum period of incubation of the special disease which has been notified, although in the case of children it is always wise to allow a good margin before permitting their return to school. If, on the other hand, the case is treated at home, the household must be kept under a certain degree of quarantine, varying according to the nature of the disease, until the last case has been pronounced free from infection, and final disinfection has been thoroughly carried out. In fixing the exact date when disinfection can be completed, it is always advisable, whenever possible, to be guided by the medical attendant.

It need hardly be said that during the quarantine period no children from an infected house ought to be allowed to attend school, though generally an exception may be made in respect to enteric fever. Exception should also be made as regards certain diseases which are often troublesome in schools, such as ophthalmia, mumps, impetigo, or ringworm. In these cases it is only necessary to detain the patient at home until complete recovery is assured. Quarantine, in a more or less restricted form, should also be insisted on as regards special occupations, notably milk-dealing, tailoring, dressmaking, and washing, when these employments are carried on in the infected house. Tradespeople, as a rule, have a great objection to notification, because they believe that publicity will injure their business; but in small towns or villages, the cases are sure to become known even if they are not reported, and any attempt at concealment will render them liable to proceedings, especially if the Notification Act is in force in the district. Notification should always be regarded as privileged information, and besides, by adopting prompt measures and paying a poor washerwoman or seamstress to nurse her sick household during the

illness, not only may much-needed assistance be afforded for the time being, but customers will duly appreciate the precautions which have been taken, and will readily renew their custom after all risk of infection has passed. Further, the Medical Officer of Health will have no hesitation in certifying that every care has been taken; whereas, if concealment has been attempted and is discovered, it often becomes his disagreeable duty to advise that proceedings should be taken either for neglecting to notify, or for exposure of infected children, or of infected articles. On the whole, then, it is greatly to the advantage of small tradespeople that early information of infectious cases should be given to the sanitary officials, even in districts where the Notification Act is not in force, because they at once obtain the best advice concerning the precautions which should be taken, and every assistance to enable them to carry on their business if that is possible, or to resume it when all risk to the public has passed. In other cases it is sometimes necessary to inform employers or other persons if there is reason to believe that due precautions are neglected.

5. *Closure of Schools.*—As infectious disease is frequently spread through school agency, Article 88 of the Education Code renders it incumbent on the managers of public elementary schools to "at once comply with any notice of the Sanitary Authority of the district in which the school is situated, or any two members thereof acting on the advice of the Medical Officer of Health, requiring them for a specified time, with a view to preventing the spread of disease, or any danger to health likely to arise from the condition of the school, either to close the school or to exclude any scholars from attendance, but after complying they may appeal to the Department if they consider the notice to be unreasonable." Sanitary Authorities, however, have no power to interfere with Sunday schools, dames' schools, or other private schools, except in so far as they may contravene clause 91 of the Public Health Act in respect to nuisance or overcrowding, or clause 126, in respect to the spread of infection; but if the Medical

Officer of Health deems it necessary that any of these should be closed for a stated time, he will always, as a rule, meet with a ready acquiescence with his instructions.

If the Notification Act is in force in a district, and isolation in hospital is available, it will seldom be necessary to close schools for prevalence of any of the notifiable diseases except scarlatina or diphtheria. In outbreaks of these diseases, however, it often happens that the early cases are of such a mild character that no medical attendant is called in, and thus either disease may assume considerable proportions before its existence is suspected. It is on this account that teachers should always be advised to exclude from school any children suffering from throat symptoms or signs of feverishness, and they should also be supplied with addressed and stamped forms in order that all such cases may be promptly notified to the Medical Officer of Health On the other hand, communications should be sent to the teacher of each school attended by children from an infected house, intimating the occurrence of the case and the nature of the disease, and requesting that such children shall be excluded until a certificate of safety is forwarded after final disinfection and termination of the period of quarantine.

Such co-operation on the part of sanitary officials and teachers will often obviate the extreme measure of closing a school by simply excluding all suspected children, and all children from houses known to be infected. Then, again, it is often possible to obviate complete closure by excluding children from particular streets, or, in country districts, from particular hamlets; or, should measles or whooping-cough be the particular disease against which precautions have to be taken, it may be advisable only to close the infant department of a school. Indeed, it may be said that these two diseases, and especially measles, are far more liable to be spread through school agency than any of the other diseases, partly because they are both infectious before the characteristic symptoms appear, and because they have not been deemed of sufficient importance to be scheduled as notifiable diseases. Measles, however, has become a far

more fatal disease than scarlatina, and school closure, especially in country districts, is the only effective measure which can be adopted to check its spread. But with regard to all of these diseases, school closure is attended with far better results in rural districts than in towns, because the pupils are scattered over a wide area, and the school is often the only focus of infection. On the other hand, it is obvious that, in more populous localities, if schools were to be closed whenever an infectious disease becomes prevalent, there are many towns in which the schools would hardly ever be open.

In respect to towns, it should also be noted that, if an outbreak of disease is confined to the scholars of one particular elementary school, it may be sufficient to close that school only. But where different schools have all appeared to aid in the spread of disease, though perhaps to an unequal extent, it may be considered advisable that all should be closed, not only for the sake of appearing to deal with all impartially, but also lest children in an infectious state, who previously attended the schools that are closed, should be sent to others that might remain open.

But apart from the exigencies of school closure depending upon the prevalence of infectious disease among children, it is sometimes necessary to close a school on account of infectious illness in the teacher's household, and also, for short periods, to permit of the rectification of any sanitary defects of a nature to extend disease, or in order that the school may be disinfected. According to the Memorandum of the Local Government Board, issued in 1897, from which the above remarks have been summarised, these temporary and occasional closures of schools are contemplated in the article of the Education Code already quoted, and are to be regarded as having a real importance of their own. (See Appendix.)

The sanitary condition of schools, it need hardly be said, should always receive the closest attention of the Medical Officer of Health, for though the Government grant is supposed to be conditioned by sound sanitation in respect to

ventilation, overcrowding, warming, lighting, water-supply, drainage, and scavenging, it too often happens that serious defects, especially in respect to outside offices, are overlooked by the Government School Inspectors, just because they assume that these matters should come under the cognisance of the Sanitary Authority. It would be far more satisfactory, and would remove the tendency to the somewhat lax inspection of these details attending a divided responsibility, if the Education Department, before awarding the grant, should insist on a certificate of satisfactory sanitary condition, signed by the Medical Officer of Health, at the same time reserving to the School Inspectors the right of making any representations which they may deem advisable. In rural districts, the sanitary condition of the outside offices is often very faulty as regards structural details, and where large ash-pit middens or privies are still permitted, the scavenging is seldom properly attended to. A dry system of conservancy and systematic scavenging can alone be considered satisfactory where trough-closets or water-closets cannot be introduced. When there is any tendency to diarrhœal prevalence, frequent scavenging should be insisted on, and disinfectants freely used.

When there is threatened prevalence of infectious disease in any district, the schools should invariably be visited. Incipient cases may thus be frequently detected, and in respect to scarlatina, children in the peeling stage may often be discovered. The teacher should keep a list of all cases which it may be necessary to exclude, together with the dates indicating the period of exclusion, and if such list is attested by the signature of the Medical Officer of Health, there is no difficulty in obtaining the grant for average attendance.

In rural districts it should be laid down as an instruction to sanitary inspectors that whenever they visit a village, they should always make inquiries at the school concerning the health of the children, and should also inspect the outside offices. It may also be observed here that disease prevention in rural and small urban districts would be

greatly assisted if the sanitary inspectors were appointed the school attendance officers instead of the relieving officers, who in most districts hold these appointments. The duties of the school attendance officer are far more closely allied to those of the sanitary inspector, and besides, the visits of the relieving officer have attached to them an implied taint of pauperism which it is manifestly unfair to inflict on the non-pauper class.

As regards the period during which it may be deemed necessary to close a school for the purposes of disease prevention, it may be laid down as a rule, especially in respect to outbreaks of scarlet fever, diphtheria, measles, or whooping-cough, that it is practically useless to certify closure for any period shorter than three weeks, and even at the end of that period it will frequently be necessary to issue a fresh certificate to continue closure. But before reopening, or issuing a fresh certificate, the Medical Officer of Health should consult the medical practitioners of the district; and this is more particularly advisable with regard to outbreaks of measles or whooping-cough, and in districts which may not have adopted the Infectious Diseases (Notification) Act.

The Association of Medical Officers of the large public schools in England have advised the following periods of isolation and quarantine in respect to the several diseases tabulated:—

	Quarantine to be required after last exposure to infection.	Earliest date of return to School after an Attack.
Small-pox	18 days	When all scabs have fallen off.
Chicken-pox	18 ,,	Ditto.
Scarlet fever	14 ,,	Six weeks, and then only if no desquamation or sore throat.
Diphtheria	12 ,,	Three weeks, if convalescence is complete, and no sore throat, albuminuria, or discharges remain.
Measles	16 ,,	Three weeks, if all desquamation and cough have ceased.
Whooping-Cough	21 ,,	Six weeks from the commencement of the whooping, if the characteristic spasmodic cough and whooping have ceased. Earlier, if all cough be gone.
Rötheln	16 ,,	Two to three weeks, according to the nature of the case.
Mumps	24 ,,	Four weeks, if all swelling have subsided.

Neither enteric fever nor typhus fever is included in this list, but in respect to both of them it may be said that the quarantine after exposure should not be less than three weeks, and the earliest date of return to school only after complete recovery.

In diseases such as ophthalmia, impetigo, ringworm, or scabies, exclusion from school should be insisted on till complete recovery is certified.

Section II.—Disinfectants and Disinfection

In the strict use of the term, a *disinfectant* may be defined as an agent which kills or renders inert the specific virus of any infectious disease. In the bacteriological sense, therefore, it may be regarded as synonymous with the term "germicide," or "bactericide." But whether the infective material is a living organism or the product of a living organism, disinfection should be restricted in its application to mean the destruction of the *activity* of both the organism

and its product. An *antiseptic*, on the other hand, is a substance which arrests putrefactive change, or impedes the growth of micro-organisms without destroying their vitality; while a *deodorant* is a substance which destroys or masks offensive effluvia, so as to render them imperceptible, or less perceptible, to the sense of smell. All disinfectants act also as antiseptics even when they are used in insufficient quantity or degree to destroy infective activity, and they may also act as deodorants, inasmuch as effluvia are frequently the by-products of bacterial growth.

There is every reason to believe that the activity of most, if not all, of the contagia is destroyed when they are freely exposed and diluted with fresh air. The virus of typhus fever, for example, is only dangerous to those who come in close contact with the patient, or in badly-ventilated and overcrowded sick-rooms. On the other hand, there is some probability that the contagium of small-pox may be wafted for considerable distances around a hospital, and more particularly when it is crowded with severe cases. But the mere fact that severe epidemics of highly infectious diseases, such as measles, influenza, and whooping-cough, entirely disappear for a time is proof that a large amount of contagium becomes inert without the aid of artificial disinfection. If, therefore, confined air is often the medium by which the specific contagia are conveyed, plentiful dilution with fresh air greatly lessens the risk of infection, and hence the importance of free ventilation, both in respect to the sick-room, when occupied, and as a valuable aid to disinfection afterwards.

But in addition to the effects of mere dilution, it is probable that the oxygen in the air exercises a direct chemical action on infective material, while other atmospheric conditions, such as dryness, temperature, and sunlight, play an important part. Thus, Koch has stated that drying is fatal to the comma bacillus of Asiatic cholera, and it is generally conceded that the contagium of yellow fever is destroyed by cold. These natural aids, however, cannot be regarded as affording any reliable protection against infection,

and they must therefore be supplemented by artificial means.

1. *Disinfection by Heat.*—While extreme cold prevents putrefactive change, and therefore acts as an antiseptic, extreme heat is destructive of all organic matter, and combustion is the most efficacious, as it is the most ancient, of all methods of disinfection. As regards infected articles of small value this is still the safest plan to pursue, but true disinfection may usually be effected by exposure to moist or dry heat at a sufficiently high temperature. Thus, the late Dr. Henry proved experimentally that the vaccine virus was deprived of the power of reproduction when exposed for three hours to a temperature of 140° Fahr., while a temperature of 120° failed to produce this effect. As a result of these and other experiments, he was the first to recommend the employment of the hot-air chamber to disinfect clothing, bedding, and the like. These experiments have been further extended by various observers from time to time, and notably by Dr. Koch in Germany, and in this country were investigated in a systematic manner by Dr. Parsons of the Local Government Board, and Dr. Klein. (See *Annual Report of the Medical Officer of the Local Government Board*, for 1884.) As Dr. Parsons's report has been published separately, it will be sufficient here to indicate very briefly the basis and methods of procedure, and the principal conclusions arrived at. In the first place, it was necessary to determine by an extended series of experiments what was the special virus or contagium which was the most resistant to every form of heat, and after trying the virus of swine-plague, tuberculosis, and anthrax, —all of which admit of being tested on animals before and after exposure to various degrees of heat,—Dr. Parsons and Dr. Klein, who was associated with him in the inquiry, satisfied themselves that the virus of anthrax was the most resistant. Having settled this point, they were able to proceed on the assumption that such apparatus or arrangements as would yield a heat sufficient to destroy the anthrax virus, not only in its bacillar but in its spore form, might

be relied upon to destroy the potency of infectious matter generally. In experimenting upon the efficiency or otherwise of the various kinds of apparatus which have been constructed for this purpose, it was seen to be necessary that the heat generated should penetrate bulky and non-conducting articles, while at the same time it would not injure or destroy the most delicate fabrics. Dr. Parsons's main conclusions are briefly these :—

(1) It may be assumed that the contagia of the ordinary infectious diseases of mankind are not likely to withstand an exposure of an hour to dry heat of 220° Fahr., or one of five minutes to boiling water or steam of 212° Fahr.

(2) Dry heat penetrates very slowly into bulky and badly conducting articles, as of bedding and clothing, the time commonly allowed for the disinfection of such articles being insufficient to allow an adequate degree of heat to penetrate into the interior.

(3) Steam penetrates far more rapidly than dry heat, and its penetration may be aided by employing it under pressure, the pressure being relaxed from time to time, or in a current, so as to displace the cold air in the interstices of the material.

(4) When dry heat is used, scorching begins to occur at different temperatures with different materials, white wool being soonest affected. It is especially apt to occur when the heat is in the radiant form. To avoid risk of scorching, the heat should not be allowed to exceed 250° Fahr., and even this temperature is too high for white woollen articles.

(5) Steam disinfection is inapplicable in the case of leather, or of articles which will not bear wetting.

(6) For articles that will stand it, boiling water may be relied on as an efficient means of disinfection. It is necessary, however, that before boiling, the grosser dirt should be removed by a preliminary soaking in water, because a high temperature, whether moist or dry, fixes organic stains indelibly in textile materials. This should be done before the linen leaves the infected place.

(7) The articles for which disinfection by dry heat or steam is especially applicable are such as will not bear boiling in water, *e.g.* bedding, blankets, carpets, and cloth clothes generally.

(8) The most important requisites of a good apparatus for disinfection by heat are (*a*) that the temperature of the interior shall be uniformly distributed; (*b*) that it shall be capable of being maintained constant for the time during which the operation extends; and (*c*) that there shall be some trustworthy indication of the actual temperature of the interior at any given moment.

(9) In dry-heat chambers, and more especially those heated by coal or coke, the first and second requirements are very often far from being fulfilled, and in very few of them did the thermometer with which the apparatus was provided afford a trustworthy indication of the temperature of the interior.

(10) In steam apparatus, the three requirements above mentioned are all satisfactorily met, and for this reason, as well as for the great rapidity and certainty of action by steam, steam chambers are greatly preferable to those in which dry heat is employed.

(11) It is important that the arrangement of the apparatus, the method of working, and the mode of conveyance to and fro should be such as to obviate risk of articles which have been submitted to disinfection coming into contact with others which are infected.

(12) After carefully experimenting with various apparatus, Dr. Parsons mentioned the following apparatus, existing at the date of his report, as giving the best results of any in their respective classes:—Of the apparatus heated by coal, the newer machine, patented by Bradford and Co., Salford, Manchester; of those heated by gas, the Nottingham self-regulating apparatus, invented by Dr. Ransom, F.R.S., and manufactured by Messrs. Goddard and Massey, Nottingham; and of those employing steam, Washington Lyon's patent steam disinfector, manufactured by Messrs. Manlove, Alliot, and Co., Nottingham.

These general conclusions, especially in respect to the great superiority of steam disinfection over the hot-air process, have been amply verified by extended observation, and notably by a series of very careful experiments conducted by Dr. Whitelegge and Dr. Ashby. By means of an electric thermometer, set to ring at 212° Fahr., and placed between sixteen or more layers of blanket, they found that in a steam apparatus the maximum interval of heat penetration indicated by the ringing of the bell was seventeen minutes; while in a hot-air chamber with twelve layers a penetration temperature of only 196° was reached after eight hours' interval, although the inlet temperature was 255°, and the outlet 245° to 250°. It therefore appears that in the best devised hot-air apparatus the penetration of heat is so slow that it is practically impossible to thoroughly disinfect articles of moderate thickness, such as pillows or mattresses; and on this account, as well as for rapidity in action, steam disinfection should be adopted for all disinfecting stations.

Of the several kinds of apparatus, now in actual use, may be mentioned the following:—

(1) Washington Lyon's apparatus consists of a strong iron chamber, oval in section, with double walls of boiler plate, and a tightly-fitting door at either end which shuts against an indiarubber collar, and is secured by screw handles so as to form a steam-tight joint. From the boiler, which is detached from the apparatus, steam is admitted first into the hollow casing or jacket, and afterwards into the interior of the chamber. The apparatus is usually worked with a pressure of ten lbs. per square inch in the jacket and five lbs. in the chamber, so that the steam in the latter is superheated in order to obviate condensation. The jacket and casing are each provided with a safety-valve and pressure-gauge, by which the pressure of steam, and therefore the temperature, can be ascertained at any moment. After the articles have been introduced and the doors securely closed, steam is first sent into the jacket so as to heat the contents of the chamber, and is then admitted into

the chamber until the gauge marks the desired temperature. It is found that penetration is more rapid if the pressure is intermitted once or twice, which is readily effected by a turning-cock. At the end of fifteen or twenty minutes the bulkiest articles are found to be thoroughly disinfected. The steam is then shut off from the chamber, but allowed to circulate for two or three minutes in the jacket, and further drying may be effected if necessary by leaving the door ajar for a short time before the articles are removed.

(2) The Geneste-Herscher apparatus, which is extensively used in France, and has been introduced into this country by Defries and Son, acts also by high-pressure steam, but there is no steam-jacket to the chamber.

(3) The apparatus of Goddard, Massey, and Warner resembles Washington Lyon's in most respects, but differs from it in the following particulars:—The chamber is rectangular, not oval in section; the doors are hollow, and by means of a jointed pipe are connected with the casing so that they form part of the steam-jacket; a separate boiler is dispensed with, the boiler being formed by the lower portion of the jacket underneath which the fire is placed; the pressure in the boiler and jacket is therefore the same —usually about twenty lbs. After the steam in the jacket has reached the working pressure, the articles are placed in the chamber and the doors are shut and secured. By means of a steam-jet at the outlet, hot air is first drawn through the chamber for two or three minutes, steam is then turned on from the jacket-boiler, which soon reaches its full pressure, and after ten to twenty minutes, according to the nature of the articles, the steam is allowed to escape and hot air is again drawn through the chamber to dry the articles.

(4) The apparatus of Van Overbeek de Meyer, is simpler in construction than either of these three. The steam is generated in a jacket-boiler which surrounds the chamber, into which it is admitted through an opening at the top, but as it is not under pressure, less strength of material is required, and safety-valves or pressure-gauges

are dispensed with. Owing to its lighter specific gravity, the steam does not mix with the cold air in the chamber but displaces it, and drives it out through an opening at the bottom. Although the temperature does not exceed 212° Fahr., the penetration, according to Dr. Whitelegge, appears to be little less rapid than at the higher temperature and pressure used with the other forms of apparatus.

(5) Reck's disinfecting chamber works at low pressure and has no steam-jacket. It has been very favourably reported on by Dr. Reid, County Medical Officer of Health for Staffordshire.

(6) In the apparatus devised by Dr. Thresh, County Medical Officer of Health for Essex, a moist temperature, exceeding that of steam at normal pressure, is obtained by adding certain saline ingredients to the water contained in the jacket surrounding the chamber,—the temperature being raised to 225° Fahr. The apparatus rests on the furnace.

These low-pressure steam disinfectors are much cheaper than the high-pressure apparatus, and it is contended that they disinfect as efficiently if not so quickly.

For these and any other form of apparatus of a stationary kind it is essential that there should be a door at each end opening into entirely separate rooms provided with separate entrances. In other words, the apparatus must be built in a divisional wall completely separating the two rooms, one of which should receive the infected articles, and no article should be allowed to enter the other room except through the disinfecting apparatus.

Portable disinfectors on wheels have also been devised for use in rural districts, but it is doubtful whether they would be of much service. Boiling all articles which can be boiled without damaging them, steeping in disinfectants, washing, and hanging out to dry, so as to have the full effects of sun and air, have to be depended on, and other articles should be burned, or buried in quick-lime.

2. *Chemical Disinfection.*—Previous to the researches of Koch and others, no precise knowledge existed concerning the relative values of the numerous chemical agents which

were indiscriminately used for disinfecting purposes. Indeed, it may be said that very few of them have been found to act as true disinfectants, while the great majority of them can only be classed as antiseptics or deodorants. The method of testing their efficiency pursued by Koch was as follows:—Threads were soaked in cultures of the spores of anthrax and other bacteria, and after being dried were placed in disinfecting solutions of various strengths and for stated periods. After this treatment, or presumed disinfection, there was final testing by cultivation or inoculation experiments, and out of a long series the following solutions only were found to have destroyed the activity of anthrax spores within a single day:—

Mercuric Chloride	1 per cent solution.		
Carbolic Acid	5	,,	,, (not in all cases.)
Potassic Permanganate	5	,,	,,
Bromine Water	2	,,	,,
Osmic Acid	1	,,	,,

Chlorine water and iodine water were also found to be efficacious when sufficiently saturated, but a 4 per cent solution of carbolic acid took three days, and a 1 per cent solution of permanganate had not acted at the end of two days.

Among popular disinfectants a 5 per cent by weight solution of the following either took several days to kill anthrax spores, or altogether failed to do so:—Chloride of lime, chloride of zinc, sulphate of zinc, sulphate of copper, sulphate of iron, boracic acid, etc. These and a long list of other substances can therefore only be classed as antiseptics or deodorants. At the same time, it does not follow that a substance is inert against the contagia of the common human infectious diseases because it fails to kill the highly resistant spores of the bacillus anthracis, but in preferring an agent which will destroy the latter, we know we are on safe ground.

(1) *Mercuric Chloride*, or *Corrosive Sublimate*.—For the chemical disinfection of excreta and soiled linen, corrosive sublimate is, by general agreement, admitted to be the most

efficacious and suitable. A solution of 1 part per 1000 is found to destroy anthrax spores. In using it, however, three precautions have to be borne in mind. In the first place, it is exceedingly poisonous, and the solution should therefore be coloured and kept in fluted bottles, labelled as poison. In the second place, as it corrodes iron and other common metals, and is instantly decomposed by them, it must be used in non-metallic vessels. In the third place, it forms an inert insoluble compound with albumen, and to obviate this the solution should be acidulated. In the Memorandum issued by the Local Government Board on the proceedings which are advisable in places attacked or threatened by epidemic disease (see Appendix) it is recommended in a foot-note that a suitable solution may be made as follows:—Dissolve half an ounce of corrosive sublimate, one fluid ounce of hydrochloric acid, and five grains of commercial aniline blue in three gallons of water. For convenient use, however, a saturated solution of the above quantities of 1 in 10 should be prepared and kept in fluted bottels, so that each bottle, when mixed in a bucketful of water (three gallons), will yield a solution of the required standard. The solution should not be further diluted, and a bucketful ought not to cost more than 3d. A solution of corrosive sublimate possesses this great advantage, that besides being the most effective disinfectant, it does not rot or stain linen steeped in it.

What is known as St. Bede's Disinfectant and the mercuric germicide of the Sanitas Company are convenient preparations of mercuric chloride. A 5 per cent solution of pure carbolic acid will, however, act as efficiently under ordinary circumstances, and also possesses the advantage of not staining linen.

(2) The several *halogens*—chlorine, bromine, and iodine —according to the experiments of Koch, Cash, and Fischer, may also be classed as true disinfectants; but chlorine is the only one which has been fairly tried in practical disinfection.

(3) *Carbolic Acid.*—Although carbolic acid is more

especially an antiseptic, Koch has recommended a 5 per cent solution for disinfecting the excreta and soiled linen of cholera patients. Phenol, cresol, creolin, Jeyes' compounds, and other substances allied to carbolic acid, may all be classed under the category of antiseptics and deodorants. *Izal*, extracted from an oil obtained from certain coke ovens, has been strongly recommended as a germicide by Notter and Frith.

(4) *Chloride of Lime* is a useful disinfectant for excreta, but too strong a solution injures clothing.

(5) *Permanganate of Potash* can only act as a disinfectant if present to the extent of 5 per cent of the whole weight of the liquid in which it is mixed, after oxidation of the organic matter. The action, therefore, of permanganate, and the solution of it known as *Condy's Fluid*, consists really in deodorisation and partial oxidation of organic matter. For articles of clothing it is objectionable on account of its staining them.

3. *Antiseptics and Deodorants.*—Apart from surgical purposes, antiseptics are used for the preservation of food, to prevent putrefactive change in organic matter, and for many other purposes. The preservation and conveyance of meat in freezing chambers is an instance of the value of extreme cold as an antiseptic. As already pointed out, all true disinfectants act also as antiseptics, but there is a long list of other reagents which, though they arrest or retard microbial growth, are not necessarily germicidal. In this category may be included certain inorganic substances, such as borax, boracic acid, and several mineral acids; almost all the essential oils, as turpentine, eucalyptus, peppermint, and cloves; alkaloidal substances, such as quinine; and other organic compounds, such as alcohol, salicylic acid, hydrocyanic acid, and aniline. Terebene, sanitas, Jeyes' disinfectants, and other well-known preparations may also be added to the list.

Although actual disinfection of sewers and drains cannot be accomplished as such, antiseptics, such as carbolic acid, Jeyes' fluid, sanitas, izal, carbolate of lime, etc., are very

useful by being employed in them at times, and when used in water-carts are very advantageous in cleansing and deodorising filthy courts, lanes, and narrow streets.

Among solid deodorants, dried earth, charcoal, quicklime, chloride of lime, and sulphates of iron, copper, and zinc may be mentioned. Charcoal possesses exceptional powers of absorbing gases and offensive odours, and oxidises very rapidly almost all oxidisable matters with which it comes in contact. Quicklime absorbs carbonic acid gas, and possibly also sulphur compounds. Chloride of lime is a very powerful deodorant, and, as already stated, can also act as a true disinfectant. The sulphates of iron, zinc, and copper act chiefly by decomposing offensive sulphides. Solution of permanganate of potash is an effectual liquid deodorant, and possesses the advantage of not being poisonous.

Among aerial deodorants, some of which also possess considerable disinfecting properties, the most important are nitrous acid, chlorine, sulphurous acid gas, and ozone.

(1) *Nitrous Acid* or *Nitrogen tetroxide*, is evolved by adding strong nitric acid, diluted with a little water, to copper filings. The nitrogen dioxide which is given off takes up oxygen from the air, and the red fumes of nitrous acid are formed. The power of oxidising organic matter possessed by nitrous acid is very great, and no disinfectant will more readily remove the smell of the dead-house. The fumes, however, are exceedingly irritant and dangerous. It has been highly recommended as a disinfectant for infected cow-sheds and pig-styes.

(2) *Chlorine* decomposes sulphuretted hydrogen and ammonium sulphide, and possesses such a strong affinity for hydrogen that it readily breaks up compounds containing that body. It also acts as a powerful bleaching agent. It has been strongly recommended by Fischer and Proskauer as much more efficacious for the disinfection of empty rooms than sulphurous acid gas, but it is not so convenient to use, and is more damaging to valuable furniture or decorations. It also appears that the action of both chlorine and sul-

phurous acid gas is greatly assisted if the air of the room is rendered moist for some time before disinfection. Chlorine is most conveniently evolved by adding strong hydrochloric acid to bleaching powder in the proportion of 3 to 2, and allowing 1 lb. of powder to every 1000 cubic feet of space, or it may be obtained by adding diluted sulphuric acid to chloride of lime.

(3) *Sulphurous Acid Gas,* or *Sulphur dioxide,* has for centuries back been the favourite disinfecting agent for empty rooms, alike on account of its cheapness and the ease with which it may be applied. It is obtained by burning small pieces of lumps of sulphur, which, in order to obtain the best results, should be well moistened with methylated spirit. Under ordinary circumstances, 1 lb. of sulphur is generally allowed for every 1000 cubic feet of space, and as this yields 11·7 per cent of the gas, it will be seen that the percentage in the contained air is much below what would be required for thorough disinfection. It must, however, be regarded as a valuable aid to the practical disinfection which is carried out subsequently to complete the process. It acts as a powerful deoxidising agent, and decomposes hydrogen sulphide, and also combines with ammonia. It may be noted here that one-pound sulphur cakes mixed with shavings, and one-pound sulphur candles, are manufactured for convenience in sulphur fumigation. Liquefied sulphur dioxide condensed in cylinders or steel syphons can now be obtained, and is more convenient for disinfecting purposes, and certainly freer from fire risks than burning sulphur. From experiments made by Dr. Kenwood and Dr. Rideal, disinfection by sulphurous acid gas appears to be far more effectual than has been supposed.

(4) *Formalin Gas.*—The *paraform lamp,* in which dry formalin tablets are burned, has been highly recommended by Dr. Kenwood and others as a very useful and convenient apparatus for disinfecting rooms. Formic aldehyde diffused by this lamp, it is asserted, possesses certain advantages in respect to diffusibility over sulphur dioxide, and is quite as efficacious as an aerial disinfectant.

(5) *Ozone* may be generated by gradually mixing 3 parts of strong sulphuric acid with 2 parts of permanganate of potash. Although it is a powerful oxidising agent, and destroys organic matter, it does not commend itself for general use.

To sweeten the air of sick-rooms, some one or other of the liquid preparations which are so commonly used, such as Condy's fluid, sanitas, terebene, or Rimmel's vinegar may be mentioned.

Section III.—Household Precautionary Measures

1. *Isolation of the Sick.*—In districts where hospital accommodation is provided, prompt removal of the patient should always be recommended, but only on the advice of the medical attendant, unless the medical officer of health deems it to be his duty to enforce such removal, under Section 124 of the Public Health Act, 1875. This, however, will rarely be necessary, and in all cases the medical attendant should certify as to the fitness of the patient to be removed. Where no hospital is available, or, when the patient can be safely isolated or treated at home, a room at the top of the house should always, if possible, be selected as the sick-room. In the homes of the poor and artisan classes such isolation is, of course, impracticable, and under these circumstances, as already stated, recourse must be had to a system of quarantine, if deemed necessary. The sick-room should be stripped of all curtains, carpets, and needless draperies or furniture, and kept well ventilated by opening windows and a fire if deemed desirable. Although of no use for practical disinfection, it is advisable as an adjunct to isolation, to hang outside the door a sheet steeped in a solution of some agreeable deodorant, such as Condy's fluid or sanitas. None but those in attendance on the sick should enter the room, and no visitors should be permitted. No child from the infected household should be permitted to attend school, or mix with the other children, until the house is disinfected, and in some cases it may be necessary

to keep other members from pursuing their usual employment. If the case is one of small-pox, special attention should be given to the necessity for the vaccination or revaccination not only of the members of the household but of persons living in adjoining houses, who are not properly protected.

2. *Nursing, Cleansing, and Disinfection.*—Persons in attendance on the sick should by preference wear cotton dresses, and should not leave the room without carefully washing their hands and changing their dresses. They should also, as far as possible, avoid associating with others. No food should be taken out of the sick-room to be used by others, nor any clothing or utensils without previous disinfection. Any effluvia in the room should be removed by free ventilation, and by the use of deodorants, such as solutions of sanitas, terebene, thymol, scented vinegar, etc., in the form of a spray or exposed in dishes, but none of these must be regarded in the light of disinfectants, and it is useless to sprinkle or use any deodorants or disinfectants in other parts of the house.

For disinfecting the discharges from the patient, bed and body linen, etc., a plentiful supply of a disinfectant solution should be provided in the sick-room, such as mercuric chloride 1 per 1000, or carbolic acid 10 per cent. For the disinfection of the excreta and secretions, an equal amount of such solution should be used, and these should at once be removed from the sick-room. In country districts, and where there is sufficient garden space, it is always advisable to bury them, especially in cases of typhoid fever, choleraic diarrhœa, small-pox, or scarlatina, but with due care not to endanger any source of water-supply.

All bed or body linen, which has been in contact with the person of the patient, should be steeped in the disinfectant solution before removal from the room, then soaked in cold water for several hours, and afterwards boiled. No articles from the infected house should be sent away to be washed elsewhere.

In wiping the discharges from the nose and mouth, soft

pieces of rag should be used and burnt immediately afterwards, or treated like the excretions.

In the event of a patient dying from small-pox or any other rapidly fatal kind of fever, the body should be enveloped in a sheet wrung out of a strong disinfectant solution on being laid in the coffin, the coffin then sealed up, and the burial should take place without delay. In such cases it is very desirable that as few persons should attend the funeral as possible, and none but those required to remove the body should enter the house.

After removal to hospital, or after recovery or death when the patient has been nursed at home, all bedding, mattresses, draperies, clothing, etc., should be at once removed to the disinfecting station, in districts where such apparatus has been provided, but where no such apparatus is available, all such articles and the room itself should be disinfected by sulphuric acid gas or some other aerial disinfectant. In using sulphurous acid gas, the following is the method usually adopted:—Spread and hang upon lines stretched across the room all articles of clothing, bedding, etc. Carefully close, and as far as possible seal up, fire-places, windows, and all crevices or ventilators; then take a sulphur cake, or 1 lb. or more of sulphur lumps, according to the size of the room, and put them in a saucer or iron dish, supported by a pair of tongs over a bucket of water; then set fire to the sulphur, close the door, and keep the room shut for six hours; after which it should be freely ventilated by keeping windows and doors open. The paper, if any, should subsequently be removed, the walls and ceiling be lime-washed, and the floor, woodwork, and furniture washed with the disinfectant solution used in the room, and soap.

Instead of sulphur, the liquefied sulphur dioxide, condensed in cylinders, or formalin gas (see *ante*) may be used, or the room may be disinfected by means of a disinfecting solution diffused by sprayers, such as those manufactured by Defries and Son. But whatever method of disinfection be adopted, the room should be left with open door and

windows, and a fire if necessary, for as long as possible afterwards, before it is reoccupied. Fresh air is perhaps more potent than any of these aerial disinfectants for antiseptic purposes, but the use of them is to be recommended because it ensures this, as well as special care in securing cleanliness.

In the homes of the working classes, and also in other homes, it is advisable that house disinfection should be carried out by the officials of the Sanitary Authority, and as far as possible, with the accord of the medical attendant. Indeed, the hygiene of the sick-room, and the isolation and nursing of the patient, as well as general instructions with regard to precautionary measures, appertain especially to the province of the medical attendant, but much assistance is afforded, and, so far as my experience goes, is welcomed, by distributing printed instructions wherever a case of dangerous infectious disease comes under the cognisance of the sanitary officials. Such instructions are best printed on cardboard, say, folded in three, because ordinary placards are apt to be torn up or mislaid, and might be headed with a list of the diseases to be notified under the Infectious Diseases (Notification), and the obligation on the part of the householder to notify if he neglects to call in a medical man; to be followed by directions with regard to whooping-cough and measles, as well as the notifiable diseases in respect to school attendance, etc.; and then, by explicit instructions concerning isolation, nursing, disinfection, etc., as above indicated. Appended to the instructions should follow the penalties for neglect to notify, and those attaching to exposure of patient while suffering from an infectious disorder, or the exposure of any infected articles of clothing, etc., without previous disinfection (see Acts in Chapter XIX.).

Such printed instructions should be as explicit and concise as possible, and should be signed by the medical officer of health, "by order of the Sanitary Authority."

For general memorandum on precautionary measures issued by the Local Government Board, see Appendix.

CHAPTER XVII

DISPOSAL OF THE DEAD

One of the most warmly contested questions in the field of sanitary reform which has attracted public attention during recent years has been the disposal of the dead. When cremation was first advocated in this country, the opposition to such an innovation on the time-hallowed custom of earth-burial was so strong and fierce that the pioneers of the movement had the greatest difficulty, not only in erecting the first crematorium in England, namely, at Woking, but in devoting it to its use after erection. In the first place, cremation was regarded as a violation of national sentiment, and a shock to one of the most cherished doctrines of religious belief, and in the second place, it was contended, and still is maintained, that it would lead to a large amount of crime which could never be detected. Time and common sense, however, have both assisted in greatly weakening the force of these objections. Even those who are most biassed by misplaced sentiment must acknowledge that whether a dead body is cremated or buried in the earth, it must eventually be reduced to its ultimate elements. Moreover, as regards the medico-legal objection, it was forcibly pointed out by Sir Henry Thompson at the London Congress of Hygiene in 1891, that, as a result of inquiries addressed to over 300 coroners, it was ascertained that only 100 exhumations had taken place in England and Wales during the course of twenty years for medico-legal purposes, and of that number only 20 bodies had been exhumed for suspected poisoning. Moreover, some of the vegetable

poisons and alkaloids are so quickly decomposed, or mingled with the ptomaines or toxins generated by the process of putrefaction, that post-exhumation evidence of their presence, sufficiently strong to convict, would be as difficult to obtain as when the body is cremated. It may be admitted, therefore, that the medico-legal objection dwindles into comparative insignificance, and there is little doubt that it could be fully met by stricter rules with regard to death certificates, official supervision, and compulsory post-mortem examination in all cases of sudden death, or when no medical man has been in attendance during the fatal illness.

But the main question at issue is not whether cremation may be permitted, but whether in the interests of national health it can lay any claim to be regarded as an imperative sanitary reform. Even admitting that it is in every respect the safest method of disposing of the dead, the advocates of the system have failed to prove that earth-burial, as it is conducted in properly regulated cemeteries, is a danger to the public health. Indeed, it cannot be too strongly emphasised that the great dangers to health lie not in the disposal of the dead, but in the unreasoning sentiment which prompts the retention of the body in overcrowded homes for as long a period as possible, and the neglect to take proper precautions, or to bury speedily, in cases of dangerous infectious disease. Neither cremation, nor what is called the rational disposal of the dead by burying them in perishable coffins, would assist in lessening these evils, which, after all, constitute the real dangers.

Speaking generally, the effect of the proximity of a burial-ground upon health is the same as that of any other accumulation of putrefying animal matter. If a graveyard is overcrowded there is the risk of nuisance effluvia when graves are opened, and pollution of the ground air of houses in the immediate neighbourhood. There are also possible risks of well-pollution, though there are no well-authenticated outbreaks of disease traceable to this cause, but under the conditions imposed by the legislature it may be said

that the public health is now duly safeguarded in all these respects.

At the same time it may be conceded that on hygienic, as well as on economical, grounds, the erection of crematories in the cemeteries of all largely populated centres would be of national benefit, so soon as public opinion indicates that there would be a demand for their use; while the efforts of those who advocate the use of perishable coffins, and who denounce excess in the direction of expensive paraphernalia, should also be encouraged as efforts in the right direction.

In the Woking crematorium, the system adopted is that of Gorini—the fuel used consisting of wood, coke, and coal; and the destruction of the body is so complete that no offensive fumes are given off. A body of average weight is reduced within an hour and a half to about 3 lbs. of inorganic ashes. These, when collected, can be preserved in cinerary urns, and removed for burial, or preservation, or they may be buried in the grounds surrounding the crematorium. Although all legal obstacles have been removed to the erection of crematoria, subject to the approval of the Secretary of State, it must be confessed that cremation, while undoubtedly growing in favour among the upper classes, finds few advocates among the people generally.

Section I.—Mortuaries

As already pointed out, the real dangers to health depend not so much on the method of ultimate disposal of the dead body, but in retaining it, especially in overcrowded homes, often until putrefaction commences, and neglecting proper precautions and speedy burial in cases of infectious disease. If a dead body is exposed to a temperature of 60° Fahr., it will begin to putrefy in three days, and give off offensive gases, and numerous cases of illness have been attributed to this cause alone, apart altogether from specific infection. Indeed it may be laid down as a safe hygienic rule that no dead body can be retained in an occupied room, or in any house which becomes temporarily overcrowded by

vacating the room in which the dead body lies, without a certain amount of risk to the health of the inmates, and this risk is obviously greatly increased when death has resulted from a dangerous infectious disease. Hence, speedy removal of the dead and mortuaries are alike necessary, and in both these directions the legislature has imposed important obligations on Sanitary Authorities throughout the country, as will be seen from the following excerpts :—

1. By Section 141 of the Public Health Act, 1875, it is enacted that any Sanitary Authority, whether urban or rural, "may, and if required by the Local Government Board, shall, provide and fit up a proper place for the reception of dead bodies before interment, and may make bye-laws with respect to the management and charges for the use of the same; they may also provide for the decent and economical interment, at charges to be fixed by such bye-laws, of any dead bodies which may be received into a mortuary."

2. It is further enacted by Section 142 that "when the body of one who has died of any infectious disease is detained in a room in which persons live or sleep, or any dead body which is in such a state as to endanger the health of the inmates of the same house or room, any Justice may, on a certificate signed by a legally qualified medical practitioner, order the body to be removed at the cost of the Local Authority to any mortuary provided by such Authority, and direct the same to be buried within a time to be limited by such order."

3. Although Sanitary Authorities outside London are empowered to provide post-mortem rooms by Section 143 of the Public Health Act, 1875, it is distinctly stipulated that such rooms shall not be in any way connected with a workhouse or public mortuary, and this proviso was deemed necessary to remove any taint of pauperism which might attach to such a situation, or to obviate any suspicion on the part of poor people that the bodies were removed for dissection purposes.

4. In London, and in all other districts in which the

Infectious Diseases (Prevention) Act of 1890 has been adopted, Section 8 of that Act renders it illegal to retain an infected body elsewhere than in a mortuary, or in an unoccupied room, without the sanction in writing of the Medical Officer of Health, or of a medical practitioner; Section 9 of the same Act prohibits the removal of infected bodies from isolation hospitals except to a mortuary or for burial if so certified by the Medical Officer of Health or medical attendant; while Section 10 empowers Justices on the certificate of the Medical Officer of Health to order an infected body, or any dead body which is retained in any house or building so as to endanger health, to be removed at the cost of the Sanitary Authority to any available mortuary, and direct the same to be buried within a time to be limited in the order. Unless the friends or relatives undertake to bury the body within the time ordered, it becomes the duty of the relieving officer to bury such body, and the Guardians may recover the expenses in summary manner from any person liable to pay them.

Such are the provisions enacted by the legislature to mitigate the prominent dangers connected with the disposal of the dead, but except it be in large towns—and even in them there is a great lack of mortuary accommodation—little or no effort has been made by Sanitary Authorities generally in this direction. It has been suggested that not only should mortuaries be provided at all hospitals, but that Sanitary Authorities should contract with hospital managers to receive bodies from overcrowded homes on payment of certain fees or of a fixed annual subscription. It would, however, be of infinitely greater service to the public generally if all Sanitary Authorities were compelled to provide mortuaries wherever they are required, and were empowered to erect these if deemed advisable in any, or every, burial-place or cemetery in their districts. Even in country parishes, the speedy removal of a dead body from an overcrowded home is as necessary as it is in towns, and there could be no insuperable objection to erecting a cheap and simple structure in every churchyard. The body could

then be removed in the night-time or early morning without ceremony, and all the expensive paraphernalia, which tell most heavily in humble funerals, could be dispensed with, except simple attendance for the burial-service at the appointed hour.

Section II.—Burial-Grounds, or Cemeteries

According to the definition laid down in several Acts of Parliament, a cemetery "is a place for the interment of the dead," or "a burial-ground," and the works connected therewith. The term, therefore, though it is generally applied to large burial-grounds, does not in its legal sense convey any meaning as regards size.

The horrible overcrowding of graveyards which existed in the early part of the century induced the Government in 1840 to appoint a commission to inquire into evils which had only become too palpable, and more especially in localities with constantly increasing populations. Since that date various enactments dealing with the subject have been passed from time to time; and among the more important of them, from the strictly sanitary point of view, may be mentioned the following:—

The Cemeteries Clauses Act of 1847 empowered "companies," or burial-boards, to obtain land by compulsory purchase for the construction, drainage, and management of new cemeteries. But there were certain restrictions and conditions imposed by the Act which were intended to safeguard the public health as far as possible, and which merit special notice because they apply to all new cemeteries constructed after that date, and are incorporated with the Public Health Interments Act of 1879.

(1) No part of a cemetery shall be constructed nearer to any dwelling-house than the prescribed distance, or, if no distance is prescribed, 200 yards, except with the consent in writing of the owner, lessee, and occupier of such house.

(2) Every part of the cemetery shall be enclosed by substantial walls or railings at least 8 feet high.

(3) The cemetery shall be efficiently drained, and for that purpose the Company is empowered to drain into any existing sewer with the consent of the persons having management of such sewer, or of the street or lands through which it passes.

(4) If any stream, canal, reservoir, aqueduct, pond, or watering-place is fouled by any offensive matter from the cemetery, the Company shall forfeit the sum of £50 for every such offence, and in addition to this penalty any person who has a right to use the water so fouled can claim a penalty of £10 during the continuance of the offence.

Section 83 of the Public Health Act, 1848, prohibited interments under or within the walls of any churches built after that date, and this clause is re-enacted by the Public Health Act, 1875.

Under the provisions of the Burial Act of 1853, Orders in Council were issued as occasion required, to close cemeteries, or burial-grounds, which were proved to have become overcrowded, and if it is desirable to close any existing burial-place, a representation must be made to the Home Secretary for the purpose of obtaining an Order under this Act.

By the Public Health Act, 1875, and other Acts, Urban Sanitary Authorities were empowered under certain circumstances to become the burial-boards of their respective districts.

The Disused Burial-Grounds Act of 1884 rendered it illegal to erect any buildings upon any disused burial-ground except for the purpose of enlarging a church or other place of public worship. Under the Open Spaces Acts of 1881 and 1887, however, all Sanitary Authorities are empowered to lay out and maintain disused burial-grounds as recreation grounds.

The closing of overcrowded burial-grounds, and the extended powers for providing new cemeteries, effected such a gradual and marked improvement in respect more especi-

ally to populous localities, that, as has already been pointed out, it may now be said there is no clear evidence of any injury accruing to the public health under the conditions enforced in modern and well-regulated cemeteries.

But overcrowding of a less pronounced, though of quite appreciable degree, kept in the meanwhile increasing as regards many of the older graveyards of rural parishes and small country towns, and to remedy these evils, all local authorities throughout England and Wales, whether urban or rural, were empowered, by the Public Health (Interments) Act of 1879, and the Cemeteries Clauses Act of 1847, with which it was incorporated, to acquire, construct, and maintain cemeteries, either within or without their districts, and are compelled to make such provision if required to do so by the Local Government Board. Although the legislature did not specify the cases in which it was thus made incumbent on Sanitary Authorities to give effect to the provisions of the new statute, the Local Government Board, in a Memorandum issued in August 1879, laid down the following as circumstances under which action should be taken :—

"(1) Where, in any burial-ground which remains in use, there is not proper space for burial, and no other suitable burial-ground has been provided;

"(2) Where the continuance in use of any burial-ground (notwithstanding there may be such space), is, by reason of its situation to the water-supply of the locality, or by reason of any circumstances whatsoever, injurious to the public health;

"(3) Where, for the protection of the public health, it is expedient to discontinue burials in any particular town, village, or place, or within certain limits."

It is further pointed out that there are other circumstances which might render it necessary or expedient to provide a cemetery, such as inconvenience of access from the populous parts of a district to the existing burial-ground, or the nature of the site, or the character of the subsoil. All these are conditions into which the Medical

Officer of Health of every district is expected to inquire, and wherever it appears to him necessary that a cemetery should be provided, it becomes his duty to report to the Sanitary Authority.

Very often in country parishes, and also as regards small towns, the difficulty is overcome by local effort at the instigation of the Sanitary Authority, either by donation of land for enlarging an existing burial-ground, or by donation of money, to purchase land necessary for the required extension. Failing local action, however, the Sanitary Authority has full power, on application to the Local Government Board, to obtain land compulsorily, and to carry out all works necessary for efficient drainage, and for these purposes can receive donations in money or land, or can borrow money on loan, the principal and interest of which have to be repaid by imposing a special rate on the particular parish or contributory place affected.

On the other hand, if it should appear desirable, upon the above or any other grounds, to close an existing burial-place, a representation must be made to the Home Secretary, as already stated, for the purpose of obtaining an Order in Council to that effect, under the provisions of the Burial Act of 1853.

It is true that the dual control, which is vested by these numerous Acts in the Home Office and Local Government Board, has in some measure crippled the progress of sanitary administration both in respect to the closing of old burial-grounds and the provision of new cemeteries; but so far as official representations are concerned, the Home Office Inspector makes it a rule to consult Medical Officers of Health concerning the suitability of any proposed new site for a cemetery within their districts, or any extension of an existing cemetery, so that conjoint action in this direction is as far as possible assured.

Before a site, which in other respects is deemed suitable, is selected, trial holes should be dug in various parts, and of sufficient depth, in order to ascertain the level of the underground water, and the nature of the subsoil. These

trial holes should be allowed to remain open for some time, and if it is found that no water stands in any of them at a depth of 8 feet from the surface, the question of drainage becomes very much simplified, because in great measure it may be dispensed with. According to a Memorandum of the Local Government Board, drawn up by Dr. Parsons, the soil should be of an open, porous nature, and free from water or hard rock to a depth of at least 8 feet. Loam and sand, or vegetable mould, make the best soil; and clay, or gravel interspersed with loose stones or boulders, the worst. The site chosen should, as a matter of course, not be in a neighbourhood in which building is likely to take place, and by preference it should stand exposed to north or north-easterly winds. The circumstances under which there might be risk of water-pollution are pointed out, such as when graves and wells are sunk near together in a shallow, superficial, water-bearing stratum of a loosely impervious nature, resting on a bed of clay; but it does not appear that the risks to which wells are exposed from the proximity of a properly managed cemetery is, in ordinary cases, great. Indeed, according to an inquiry instituted by the State Board of Health of Massachusetts, it was found that, out of seven wells sunk in sandy and gravelly soil, varying in depth from 4 to 17 feet, and at distances from 10 to 400 feet from the nearest grave, only one was found to show undoubted signs of contamination, and this was 10 feet from the nearest grave. This tends to prove that, even in respect to old graveyards, the dangers to well-pollution, unless a well happens to be in close proximity, is comparatively small; while, in respect to new cemeteries, all such risk would be avoided by the minimum distance of 200 feet from the nearest house being insisted on. The chief risk of pollution would arise from draining a cemetery into a brook used for drinking purposes, but this also is prohibited under heavy penalties, as has already been pointed out, by special sections of the Cemeteries Clauses Act.

As regards other conditions, it is recommended that, in new cemeteries, a strip of ground, 15 to 20 feet wide all

round, should be kept free from interments on the interior of the boundary fence, which would afford space for a gravel or asphalt walk, and a fringe of trees, plants, or shrubs next the fence.

In respect to the amount of land necessary, the minimum required is usually estimated at an acre of land to serve for fourteen years for every thousand of the population concerned.

To prevent overcrowding, and ensure deodorisation and natural decomposition of the bodies, the following regulations were issued by the Home Office in 1863 for grounds or cemeteries under the Burial Acts:—

The grave spaces for persons above twelve years of age shall be at least 9 feet by 4 feet (4 square yards); under twelve years of age, 6 feet by 3 feet, or 4½ feet by 4 feet (2 square yards). There must be at least a foot between each grave.

No unwalled grave shall be reopened within fourteen years after the burial of a person above twelve years of age, or within eight years under twelve, unless to bury another member of the same family, in which case a layer of earth, not less than 1 foot thick, shall be left undisturbed above the previously buried coffin.

No coffin shall be buried in any unwalled grave within 4 feet of the surface of the ground, unless it contains the body of a child under twelve years of age, when it shall not be less than 3 feet below the level.

So long as earth-burial is carried on under these conditions, there need be no dread of either water-pollution or the propagation of disease by infected bodies after interment. Indeed, it may be said that this microbial scare which cremationists have endeavoured to attach to earth-burial is based solely on the oft-quoted instance that Pasteur succeeded in isolating the bacillus of anthrax from the earth, and that sheep, sojourning on a plot of ground where animals with anthrax had been buried, succumbed to the disease. Pasteur, in this instance, considered that the spores were conveyed to the surface by earth-worms, and Darwin's researches no doubt lent some considerable weight to this view, but Klein has recently shown that spores are not formed under such conditions, and that the rapid onset

of putrefaction soon destroys all infectivity. But apart altogether from theories, the fact remains that earth-burial, under proper conditions, or indeed under very lax conditions, has not been productive of any well-authenticated outbreaks of specific disease, and even the semblance of such an outbreak has not been discovered to emphasise the wordy warfare which has of late years been carried on between the advocates of cremation and the supporters of Mr. Seymour Haden's "earth-to-earth" system.

In the face of a sentiment which is the hereditary outcome of centuries of actual belief, there is no likelihood that earth-burial will be discontinued for generations to come, and the plea for cremation, as an alternative system, would gain far more support if Mr. Seymour Haden's contentions were frankly admitted—that brick graves, vaults, leaden shells, and heavy oak coffins are all opposed to true hygienic principles, because they only retard, but do not prevent, decomposition, and always befoul natural decay.

CHAPTER XVIII

VITAL STATISTICS

VITAL statistics may be defined as the science of figures applied to the health-history of communities. They deal with the principal events or phenomena of human life,—the births, marriages, and deaths; the various diseases from which people suffer or die, together with all the influences which affect vitality. In other words, the units of which they are composed consist mainly of persons living and of persons dead, and these units are classified or grouped under certain definite characteristics, such as age, sex, place of residence, occupation, and disease. The analysis of these units or elementary facts, observed in their various relations to time and place, and dealt with according to strict numerical method, lies at the foundation of all sound inquiry, and supplies the only true criterion of sanitary progress.

SECTION I.—SOURCES OF INFORMATION

In briefly discussing this subject, for the purposes of the health officer or sanitarian, it will be convenient to refer at the outset to the two main sources from which the data which constitute vital statistics are derived, namely, the census returns, and the returns of births, marriages, and deaths, supplied by registration. As all these returns particularise the locality of every unit, whether supplied by census or registration, the units themselves can be readily classified according to various divisions or subdivisions of the country, such as counties, towns, unions, parishes,

villages, or streets, or according to urban and rural districts, as defined by the Public Health Act, 1875. For purposes of registration the country is divided into registration and sub-registration districts, which bear a more or less definite relation to counties, towns, and unions; while for sanitary purposes the particular returns, which apply to every district, however small or however large, can be obtained by every sanitary authority throughout the country from the district registrars. The management of the census, and the entire charge of the vital statistics of the United Kingdom, are entrusted to three Registrars-General, viz. one for England and Wales, one for Scotland, and one for Ireland, who publish yearly and quarterly reports for the whole country, and weekly reports for certain large towns.

1. *The Census.*—The census, or actual enumeration of the people, is effected in Great Britain every ten years. The first enumeration was made on 10th March 1801, and the last on 5th April 1891, so that the last census was the tenth enumeration of the inhabitants of this country. In order to secure accuracy of returns it is essential that the census should be taken rapidly and simultaneously; and this is effected by issuing schedules to every householder beforehand, who has to enter all the particulars concerning every one sleeping in the house on the night of the date fixed for the census. These schedules are all scrutinised and collected on the following day by the appointed enumerators, and in due course forwarded to the office of the Registrar-General, where they are tabulated and made available for statistical purposes.

It need hardly be said that the taking of a census does not consist merely of a simple enumeration of the people. Amongst other items, the schedule returns contain particulars of the name, sex, age, rank, profession or occupation, condition, relation to head of family, and birthplace of every living person who passed the night of the date of the enumeration in every house throughout the kingdom. When these returns are fully classified and analysed, they not only give the number of inhabited and uninhabited houses in

every parish, town, union, or county throughout the kingdom, together with the number of inhabitants, but the population can be grouped according to age, sex, occupation, etc., thus supplying a vast storehouse of statistical information, which is of the highest value.

The following table, from the Preliminary Report of the 1891 Census, is interesting as showing the growth of the population of England and Wales, and the enormous increase in the population of London, during the present century. The figures for 1897 represent the population as estimated by the Registrar-General for the middle of the year :—

Year of Enumeration.	Population in England and Wales and in London at the Ten Enumerations.		
	England and Wales.	London.	Persons in London to 100 in England and Wales.
1801 . . .	8,892,536	958,863	10·78
1811 . . .	10,164,256	1,138,815	11·20
1821 . . .	12,000,236	1,378,947	11·49
1831 . . .	13,896,797	1,654,964	11·91
1841 . . .	15,914,148	1,948,417	12·24
1851 . . .	17,927,609	2,362,236	13·18
1861 . . .	20,066,224	2,803,989	13·97
1871 . . .	22,712,266	3,254,260	14·33
1881 . . .	25,968,286	3,814,571	14·69
1891 . . .	29,001,018	4,211,051	14·52
1897 (Estimated) .	**31,055,355**	**4,463,169**	**14·37**

The aggregate population of England and Wales at the last census, including the population of London, consisted of 14,050,620 males and 14,950,398 females, showing an excess of females over males of 899,778.

What is called " the natural increment " of the population is represented by the excess of births over deaths, while " the actual increment," which is always influenced to some slight extent by the balance between emigration and immigration, can of course only be determined by enumeration. Estimates of population, therefore, and especially of different localities, can never be relied upon as strictly accurate. If, for example, the rate of increase of the population had remained as it was during 1871-81, the addition to the

population would have amounted to 3,729,929, whereas it was only 3,026,579, so that the estimated population at the beginning of April 1891 was 703,350 in excess of the actual population. This decline in the rate of growth was found to be due partly to a falling off in the "natural increment," and partly to an increase in the excess of emigrants over immigrants. The report also shows that the decline in the natural increase was not due to increased mortality, for the annual death-rate in 1881-91 was lower than in any earlier decennium, but to a persistent decline in the birth-rate, which was unprecedentedly low.

2. *Method of Estimating Populations.*—Having pointed out so much concerning the actual census of the people, it becomes necessary now to refer to the method of estimating populations adopted by the Registrar-General for years intervening between one census enumeration and the next. This method of calculation is based, as regards the country generally, and large populations, on the assumption that the rate of increase or decrease which prevailed between the last two census enumerations will be maintained until the next census is taken. The estimate of the population of a town or sanitary district thus obtained becomes the basis upon which the birth-rate, death-rate, and other rates are calculated, and it need hardly be said that the nearer the estimate approaches the actual number of the population the more strictly reliable will be the statistical results. The method pursued by the Registrar-General requires the use of logarithms, and may be briefly illustrated as follows:—

If, for example, the population of any district is 100,000 at the beginning of any given year, and becomes 101,000 at the end of that year, it is evident that at the beginning of the third year it will be greater than 102,000, inasmuch as the yearly rate of increase must now be reckoned on 101,000, and not upon 100,000 as at starting. The problem, in fact, resembles one of compound interest, in which the capital by addition of the interest becomes greater each year, and consequently the amount of interest itself increases year by year, while the rate remains the same. In

other words, a population increases in regular geometrical progression when the births exceed the deaths, and the ratio of the births to the deaths remains constant.

To put it algebraically, let P represent the population at the beginning of any given year, and r the net annual increase per unit of population, it will be at once evident that for every unit at the beginning of the year, there will be $1+r$ at the end of that year or the beginning of next year, and the population has now increased to $P(1+r)$. Then, assuming that the same rate of increase continues in the second year, the population at the end of that year will be obtained by the formula:—

$1 : 1+r :: 1+r : (1+r)^2$, and population $= P(1+r)^2$.

At the end of the third year it will be represented by $1 : 1+r :: (1+r)^2 : (1+r)^3$, and population $= P(1+r)^3$.

Further, if n be taken to represent any number of years, it will now be evident that the population at the close of the nth year will be $P(1+r)^n$.

In order to apply these formulæ to any given population, the only data required are the enumerations at the two previous censuses; but as populations are estimated at the middle of the year, and the census is taken at the end of the first quarter, the quarterly increase must also be taken into account.

Let P represent the census of a population in 1881, and P′ the census of the same community in 1891, then if r = annual rate of increase per unit and $R = 1+r$ = annual *increment* of each unit per annum, it is clear that $P(1+r)^n = P\ R^n = P'$.

But in this case $n = 10 \therefore P\ R^{10} = P'$, and $R^{10} = \frac{P'}{P}$ = rate of *decennial* increase; $R = \sqrt[10]{\frac{P'}{P}}$ = rate of *annual* increase; and $\sqrt[40]{\frac{P'}{P}}$ = rate of *quarterly* increase.

Hence to express these several formulæ in logarithms:— Log. $P + 10$ log. $R =$ log. P'. Therefore log. $R = \frac{1}{10}$ (log. P' − log. P) = log. rate of annual increase, and $\frac{1}{40}$ (log. P' − log. P) = log. of rate of quarterly increase.

Thus the logarithm of the estimated population at the

middle of 1891 is log. $P' + \frac{1}{40}$ (log. $P' -$ log. P), and the estimated population of the middle, say of 1894, would be, log. $P' + \frac{1}{40}$ (log. $P' -$ log. P) $+ 3$ [$\frac{1}{10}$ (log. $P' -$ log. P')].

In more general terms the rule for estimating the population of any community may be stated as follows:—From the logarithm of the most recent census, subtract the logarithm of the previous census, and then divide the logarithm so obtained by 10, and the quotient will be the logarithm of the ratio of annual increase. Add $\frac{1}{4}$ of this to the logarithm of the last census, and the sum will be the logarithm of the population at the middle of the census year. To this sum add the logarithm obtained by multiplying the logarithm of the rate of annual increase by the number of years intervening since the last census, and the sum will represent the logarithm of the estimated population at the middle of the required year.

For example, suppose that the population of a town at the 1881 census was 240,000, and at the census in 1891 it had increased to 284,500, what will be the mean population in 1894?

(1) Log. pop. (1891), 284,500 = 5·4540823.
(2) Log. pop. (1881), 240,000 = 5·3802112.
(3) By subtraction, log. rate of decennial increase = 0·0738711.
(4) Dividing by 10, log. rate of annual increase = 0·0073871.
(5) Again dividing by 4, log. rate of quarterly increase = 0·0018468.
(6) The sum of log. pop. 1891 (1) + log. rate of quarterly increase (5) + 3 log. rate of annual increase (4) = 5·4780904.

From the tables of logarithms the number corresponding to 5·4780904 is found to be 300,670, which would therefore be the estimate for the middle of 1894.

If it is desired to find the time in which a population will double itself, that is, in which P' will become equal to 2P, the formulæ above given will apply. Thus—

$$P' = P\ R^n$$
$$2\ P = P\ R^n$$
$$\therefore R^n = 2$$

$$n \log. R = \log. 2$$

$$\text{and } n = \frac{\log. 2}{\log. R} = \frac{\log. 2}{\log. (1+r)}$$

where r = the annual rate of increase per unit of population, and n = number of years in which a population will double itself.

The assumption, however, that the same rate of increase will hold good in any locality as throughout the previous decade is by no means borne out by actual figures when another census is taken. Some populations may remain stationary, others decline, while others may increase rapidly owing to new industries springing up, or to a large influx of residents, as in popular health-resorts. Again, in the centre of large towns, there may be, and often is, an actual decrease in the population, owing to the displacement of dwellings by business premises, and the opening up of new streets, whereas the outlying suburbs may show an increase far and above that afforded by the actual excess of births over deaths. According to the census returns for 1891, the increase in the urban districts during the last decennium amounted to 15·3 per cent, while the increase among the inhabitants of the rural and suburban districts was only 3·4 per cent. Indeed, in many rural districts there has been a considerable decrease, owing to the steady migration of adults into the towns.

In small and slowly-increasing districts the following method of calculation, though fallacious for towns of any size, will give a fairly approximate estimate of the population:—Add to the population of the district as enumerated at the last census a tenth of the difference between that number and the number obtained at the previous census, for each year that has elapsed since the last census. This will give the estimated population for the end of the first quarter of any given year; but inasmuch as the death-rate is calculated on the estimated population of the district at the middle of any year, it is evident that a fourth part of the annual increment, or a fortieth part of the actual

increase, of population which has taken place between the two censuses must be added to represent the increment for the additional quarter.

As regards new and rapidly-increasing districts, however, neither method of calculation will yield approximately accurate results, and in such cases it is desirable, when possible, to ascertain the number of inhabited houses at the end of the half-year ending March, and the half-year ending September, when the rates are collected, and these particulars can be procured from the assessment books. A fairly correct estimate of the population can then be obtained by taking the mean of the number of inhabited houses at these two dates to represent the number at the middle of the year, and then multiplying the average number of inhabitants per house, which can be ascertained from the last census returns.

In the case of large towns, if the estimated population is suspected to be wide of the mark, some indication of this will be given by a marked departure from the average birth-rate or death-rate; by the number of inhabited houses as obtained from the rate-books; by returns of school attendance; or by the condition of local industries.

It need hardly be pointed out, that as every calculation in vital statistics rests on the assumption that the population is accurately known, the trustworthiness of all calculated estimates diminishes as the interval from the last census increases. A quinquennial census, therefore, is much to be desired, and it would be advantageous in many respects to have the census taken at midsummer, and not at the close of the first quarter.

3. *Registration.*—Ever since the days of Queen Elizabeth, births, deaths, and marriages have been registered in the different parishes throughout England; but it was not till the year 1837 that the Legislature passed an Act which provided that for the future all these entries should find a place in a national register, and that as regards deaths the various causes or diseases should be certified by the medical attendant. That the important office of the Registrar-

General of England, which was established by that Act, has been productive of a vast amount of benefit to the health of the nation, and indeed has largely stimulated other countries to follow in the wake of sanitary progress, there can be no doubt. The first Annual Report of the Registrar-General, which was drawn up by the late Dr. Farr, appeared in 1839, and from the date of his appointment as Superintendent of the Statistical Department up to the date of his retirement in 1879, his was the master-mind which, by a wide yet accurate induction from statistical data, laid the foundations of public hygiene, and at the same time enlarged and established the principles of medical science.

In England and Wales there are over two thousand registrars and superintendent-registrars, whose duty it is to collect and forward to the central office at Somerset House all the certificates returned to them throughout the country. These, as already stated, apply to births, marriages, and deaths.

(*a*) *Registration of Births.*—The chief data in these returns are the sex, the date of birth, the place of birth, the number of births (twins or triplets), legitimacy, and the residence of the parents. According to the Births and Deaths Registration Act, 1874, all births must be registered within 42 days of their occurrence.

(*b*) *Registration of Marriages.*—These returns give the name, age, occupation, residence, and condition of husband and wife.

(*c*) *Registration of Deaths.*—The principal data in these returns are the date, name, residence, age, sex, occupation, condition (whether single, married, or widowed), and the fatal disease or cause of death. Deaths must be registered within five days of their occurrence.

In the case of children the age is stated in days, weeks, or months up to two years. But of all the data the most important to the hygienist is the cause of death, which has to be certified by the medical attendant, or, in cases of inquest, by the coroner. To ensure accuracy of statistical results it is highly essential that the cause of death should

be clearly diagnosed, and certified according to the nomenclature of diseases drawn up by the Royal College of Physicians, and adopted by the Registrar-General. But it must be confessed that, apart from errors in diagnosis, which frequently occur, the cause of death is too often certified in a haphazard sort of way, and with but little regard to correct medical terminology. As a rule, however, these inaccuracies apply for the most part to causes of disease which do not come under sanitary control; and in this respect, therefore, they do not vitiate statistical results to any appreciable extent, except when the primary cause of death is not certified. For example, a case of enteric fever often succumbs to pneumonia; a case of scarlatina to nephritis; a case of measles or whooping-cough to bronchitis; a case of phthisis to diarrhœa; a case of rheumatic fever to endocarditis—and so on. Now, in all such cases it is of the utmost importance that the primary cause should be certified as well as the secondary, because the former is the cause which should be classified as the actual cause of death. Accuracy of data, uniformity of data, and completeness of data, are all of them indispensable to correct statistical analysis.

But, in addition to the registration of deaths, it has long been urged by leading sanitary reformers, that no true estimate of the vitality of the nation can be formed, unless a national system of registration of cases of sickness is also established. It is true that to a certain limited extent this has been attempted by the Local Government Board, but as these returns only apply to pauper sickness they are of little public value. Of far greater importance is it for purposes of sanitary defence that the Infectious Diseases (Notification) Act of 1889, which has now been adopted in the great majority of sanitary districts, should be made compulsory throughout the country as it is in London, and now also throughout Scotland, because without prompt information of early cases, preventive measures are seriously crippled and especially in districts where proper hospital accommodation has been provided.

Section II.—Classification

The data thus obtained are classified or grouped under various headings. For example, so far as the duties of the medical officer of health are concerned, the births are classified according to sex, and whether legitimate or illegitimate; while the deaths are classified according to residence, sex, ages, occupations, and diseases. In large urban districts the system of classification usually adopted is that of the Registrar-General, but for small urban or rural districts the limited tabular returns required by the Local Government Board will be sufficient. In either case, however, printed forms should be used for classification, and arranged to contain all the data for weeks, months, or quarters. (See Appendix.)

In classifying data of any kind, it is essential that the individual units should have precise and definite characters, so that every unit in a group should be strictly included in that group. Then, again, the dividing character of every group should be so distinct and clearly defined as to afford no room for doubt under which group or heading every unit should be classified. Care also should be taken that no unit should be classified so as to appear in two allied groups at the same time. Thus, we will suppose that a death has been returned as due to phthisis as the primary, and diarrhœa as the secondary, cause; it would obviously vitiate the results if the single case were classified under the heading of diarrhœa, and also under that of phthisis. It should be classified under the heading of phthisis only.

Section III.—Statistical Results and Deductions

After the data or units have been correctly classified, it becomes possible to compare and discuss their numerical relations. For this purpose a constant numerical standard must be adopted, and in vital statistics it is the rule to state this relation, or rate, as so much per cent or per 1000, or some other multiple of 1000.

1. *Birth-rates.*—The birth-rate of a population or community is obtained by comparing the total number of births occurring in a year and the total population estimated, as previously shown, at the middle of the same year. It is usual to represent it as a rate per 1000 of the population living in the district, at all ages. Thus we will suppose that the estimated population of a district is 11,902, and that the number of births registered in the district during the year amounted to 384, then the birth-rate is obtained as follows:—

$$11{,}902 : 1000 : : 384 : X,$$

or annual birth-rate per 1000

$$= \frac{384 \times 1000}{11{,}902} = 32{\cdot}2.$$

The birth-rate in England and Wales in 1897 was equal to 29·7 per 1000 persons estimated as living at the middle of the year, and lower than that in any year since 1874, when it was 36·3 per 1000. The rate of illegitimate births is generally represented as a percentage of the total number of births, or it may be represented per 1000 persons living. Taking the whole of England and Wales, and neglecting decimals, one child out of twenty is born out of wedlock, but the rate of illegitimacy is declining.

Male births are everywhere more numerous than female, but in England and Wales the proportion of boys to girls is smaller than in any other European country, the proportion being 104 boys to 100 girls.

The high birth-rates which prevail in large urban districts are in great measure due to the fact that the marriage-rate is higher, and that women marry younger than they do in country districts; while another cause which no doubt operates to a considerable extent is the high rate of infant mortality, thus shortening the intervals of child-bearing, by the early deaths of the new-born. In fashionable towns, where large numbers of unmarried servants are employed, and where a large proportion of the residents are retired people, the birth-rate is always very low.

2. *Marriage-rates.*—This, like the birth-rate, is usually calculated at a rate of persons marrying per 1000 of the population living in the middle of the year. The average marriage-rate in England and Wales during the ten years 1871-80 was 16·2 per 1000. During the five years 1881-85 it had fallen to 15·1, and during 1886-90 it had still further fallen to 14·7 per 1000.

3. *Mortality.*

(1) *Crude Death-rates.*—What is called the crude death-rate, or recorded annual death-rate, of any district or community, is determined by means of a ratio between the number of deaths occurring during the year and the estimated population in the middle of the year, and, like the birth-rate, is represented as a rate of so many deaths per 1000 of the estimated population. Thus, we will suppose that the estimated population of a district amounts to 22,151, and that the number of deaths which occurred in the district during the year amounted to 335, then the total annual death-rate would be calculated as follows :—

$$22{,}151 : 1000 : : 335 : X,$$

$$X = \frac{335{,}000}{22{,}151} = 15{\cdot}1,$$

where X represents the total annual death-rate per 1000.

The death-rate in England and Wales in 1897 was 17·4 per 1000, and lower than that in any previous year, except 1894 and 1896.

In estimating the death-rate of a large town divided into several sub-districts with different populations and different death-rates, it would be manifestly erroneous to take the average of the several death-rates as representing the total death-rate. Either the whole of the deaths occurring in the several districts must be added together and the death-rate calculated on the total population, or the calculation should be made as follows :—Let a, b, c represent the component parts of a population, and let x, y, z represent the different death-rates per unit of the population respectively :—

Then the number of deaths in $a = ax$, in $b = by$, and in $c = cz$; therefore the total number of deaths in $a + b + c = ax + by + cz$, and $\frac{ax+by+cz}{a+b+c}$ = death-rate per unit for the whole.

This may be illustrated by the following problem:—If in a town with a total population of 80,000 one district, a, with a population of 30,000, has a death-rate of 18 per 1000; another district, b, has a population of 40,000 with a death-rate of 20 per 1000; and a third district, c, has a death-rate of 10 per 1000 and a population of 10,000—what is the death-rate for the whole town? Here $\frac{ax+by+cd}{a+b+c}$ = total death-rate per unit of total population. Therefore $\frac{(30,000\times\cdot018)+(40,000\times\cdot020)+(10,000\times\cdot010)}{80,000} \times 1000 =$ total death-rate per 1000 of population $= \frac{540+800+100}{80} = 18{\cdot}0$. If, however, the average of the several death-rates had been taken the total death-rate would have been expressed as 16·0 per 1000.

It thus appears that in estimating the death-rate of a total population when the death-rates of the component parts are given, the calculation must be based on the relative proportion existing between the component parts, and it is only when those parts are equal that the mean of the several death-rates would represent the total death-rate.

In the great majority of sanitary districts the recorded annual death-rate does not represent the *actual* death-rate, and corrections must be made for deaths of persons not belonging to the district, which occur in hospitals, workhouses, asylums, or among visitors, and for the deaths of persons belonging to the district which occur outside the district. Take, for example, the statistics of a town of some 10,000 inhabitants in the centre of a union of some 55,000 inhabitants. The town is a separate sanitary district, but contains the workhouse for the whole union. It is evident that the death-rate for the town would be represented as larger than it really is if no correction were made for the deaths which occur in the work-house; while, on the other hand, the death-rate of the surrounding rural district would appear less than it actually is, unless the quota of indoor pauper deaths belonging to it is added to the total number of deaths. To make these corrections the statistics of

deaths occurring in these institutions, giving full particulars of age, sex, and residence, must be obtained. Further, it should be noted that if the institutions in a district are large, and receive the great majority of their inmates from other districts, the population of the institutions should be deducted from the total population before calculating the annual death-rate. (See Table A in Appendix.)

So far, then, the problem of calculating the annual death-rate of any town or district becomes a very easy matter when the statistics are summarised for a whole year. But in respect to some large towns it is customary for the health officer to publish weekly, monthly, or quarterly reports; and as all the rates given in these reports are calculated as annual rates per 1000 of the population living in the middle of the year, the problem becomes considerably more complicated. When monthly reports are submitted, some medical officers of health calculate the annual rates by taking five weeks for the months of March, June, September, and December, and four for the other months; but this method, though convenient, is not strictly accurate, and it is much preferable to adopt the method pursued by the Registrar-General. This assumes that all the rates published, whether they relate to a year, a month, or a week, are annual rates to 1000 persons living, and represent the number of persons who would die in the year in 1000 of each population, if the proportion of deaths to population recorded in the shorter periods of a week, a month, or a quarter, were maintained throughout a whole year. Now the correct number of days in a natural year is 365·24226, and the number of weeks in a year is 52·17747. The Registrar-General, therefore, divides the estimated population of each of the large towns, whose rates are published weekly, by 52·17747, and thus obtains what may be called the weekly population of the town, which is assumed to remain constant throughout the year. Thus, if the estimated population of a town for a given year is 267,881 persons, its weekly population for the year is

$$\frac{267,881}{52{\cdot}17747} = 5134.$$

Then, if the deaths in any given week amount to say 127, the total annual death-rate per 1000 would be

$$\frac{127 \times 1000}{5134} = 24{\cdot}74.$$

In the same way, to calculate the annual death-rate for any given month or quarter, the total estimated population is divided by 365·24226 to obtain what may be called the daily population for the year, and this number is used in arriving at the population for any given month or quarter, inasmuch as the length of a month varies from 28 to 31 days, and of a quarter from 90 to 92 days. To facilitate these calculations, the daily and weekly populations may be expressed in logarithms which would remain as constants during the year. Thus in the above example

log. 127,000 − log. 5134 = log. of annual death-rate.

or

5·1038037 − 3·7104559 = 1·3933478 = 24·74.

In his published quarterly returns the Registrar-General makes his death-rates for each quarter refer to the thirteen weeks corresponding most nearly with the natural quarter; and the quarterly population is obtained by multiplying the weekly population by 13.

In addition to the birth-rate and death-rate, the other rates which should be given, even in the most restricted annual reports of medical officers of health, are the death-rate from zymotic disease, and the rate of infant mortality.

(2) *Zymotic Death-rates.*—What is called the death-rate from the seven principal zymotic diseases, or zymotic death-rate, is based on the total number of deaths occurring in a district during the year due to small-pox, measles, scarlatina, diphtheria, whooping-cough, fever (typhus, typhoid, and other or doubtful forms of continued fever), and diarrhœa. This, like the birth-rate or total annual death-rate, is calculated on the estimated population of the district, and is

expressed as so many per 1000. Thus, we will suppose that in an estimated population of 22,438 the deaths from the seven principal zymotic diseases amounted to 48 during the year; the zymotic death-rate in this instance would be:—

$$\frac{48 \times 1000}{22{,}438} = 2{\cdot}1 \text{ per } 1000.$$

According to the returns of the Registrar-General, the mean annual death-rate from the seven principal zymotic diseases in England and Wales in the three decades 1851-60, 1861-70, and 1871-80 was 3·87, 4·11, and 3·36 per 1000 respectively, while during the ten years 1881-90 it has fallen to 2·35.

The following table, from the Supplement to the fifty-fifth annual report of the Registrar-General, shows that during the ten years 1881-90, the urban portion of England differed very materially from the rural portion, not only with respect to the mortality from all causes, but also with respect to the mortality from the seven principal zymotic diseases.

BIRTH- AND DEATH-RATES PER 1000 LIVING IN ENGLAND AND WALES, IN URBAN ENGLAND, AND IN RURAL ENGLAND RESPECTIVELY (1881-90).

	Births.	Deaths from all causes.	Small-pox.	Measles.	Scarlet Fever.	Diphtheria.	Whooping-cough.	Fever.	Diarrhœa.	Deaths under one year to 1000 Births.
England and Wales	32·3	19·1	·45	·44	·33	·16	·45	·23	·65	142
28 towns . .	33·1	21·5	·88	·62	·40	·19	·61	·26	·89	162
50 towns . .	33·6	19·7	·27	·49	·38	·10	·41	·26	·72	153
Urban England (78 towns) .	33·0	21·1	·74	·59	·39	·16	·56	·26	·85	160
Rural England .	31·2	17·6	·24	·32	·28	·15	·36	·21	·52	128

The annual death-rate from any other group of diseases, or from any single disease such as cancer or phthisis, is calculated in the same way as the zymotic death-rate.

(3) *Rate of Infant Mortality.*—The rate of infant mortality, in the returns of the Registrar-General and in most health reports, is measured by the proportion of deaths of infants under one year to births registered, and is expressed as so many per 1000 births. Thus, we will suppose that the total number of deaths of children under one year of age which occurred in a given district amounted to 112 during the year, and that the births registered during the year amounted to 898, the rate of infant mortality estimated in this way will therefore be—

$$898 : 1000 :: 112 : X,$$

or

$$X = \frac{112 \times 1000}{898} = 124.$$

The average annual rate of infant mortality in England and Wales for the ten years 1881-90 was equal to 142 per 1000 registered births, while the average rate for the ten years 1871-80 was 149 per 1000.

Most of the causes of infantile mortality are common to every locality, but are more prevalent in large towns than in small urban or rural districts. Such as—

(*a*) *Early marriages* and weakly parents.

(*b*) *Hereditary tendencies, e.g.* syphilis, scrofula.

(*c*) *Insanitary surroundings and unfavourable social conditions, e.g.* poverty, vice, drunkenness, uncleanliness.

(*d*) *Improper feeding.*—In manufacturing towns the employment of women in mills and factories during pregnancy, and shortly after childbirth, has a most disastrous effect on the welfare of their infants, which are often sent out to nurse during the day, and are improperly fed or neglected. Indeed, improper feeding may be set down as the chief factor in producing infantile mortality amongst all classes, but more especially amongst the poor and ignorant. The improper substitution of farinaceous foods

during the early period of infant life, and the use of uncleanly bottles for feeding with milk, contribute largely to the mortality from diarrhœa, marasmus, and convulsions.

(*e*) *Insufficient clothing and exposure.*—There is no doubt that the high mortality among infants from bronchitis and pneumonia during severe weather is largely due to want of proper clothing, and the reckless exposure to which they are subjected.

(*f*) *Infant life insurance.*—There can be little question that this sinister form of thrift tempts to culpable neglect in the care and nursing of infants, and the fact that there is a much greater mortality among insured than among uninsured children proves that this baneful system constitutes an additional hazard to infant life.

(4) *Death-rates at various groups of ages.*—The death-rate of children under five years of age is sometimes expressed as a percentage of the total number of deaths, which is a very fallacious method. To be of real value, it should always be expressed as a rate per 1000 of the estimated number of children under five years living in the middle of the year. Indeed, what is called the age-distribution of populations is the only real basis on which the relative value of death-rates can be determined.

A great deal of needless controversy has arisen on the influence of birth-rates on death-rates, but practically the birth-rate only affects the death-rate in so far as it affects the age-constitution of the population of any given town or district. In rapidly increasing towns, for example, a low birth-rate may coincide with a low death-rate, on account of the influx of people between fifteen and thirty-five years of age, and therefore of lower mortality; or again, if a high birth-rate be continued for any length of time it means that there is a large proportion of people at the reproductive age and of young adults, whose low mortality would more than counterbalance the high mortality among children. If a high death-rate coincides with a high birth-rate, it is reasonable to infer that the infant mortality is excessive, but there is no constant causal relation between the two,

any more than there is between a low birth-rate and a low death-rate; the age constitution of a population alone governs its death-rate.

But the mortality rate of different localities is also affected to some extent by sex-distribution, because at nearly all ages the death-rate of females is lower than that of males. Hence an excess of females, as in residential localities where there is a large number of domestic servants, must tend to lower the death-rate, apart from the greater influence attaching to their effect on the age distribution of the population. Generally speaking, the influence of age and sex-distribution favours a low mortality in rapidly-increasing towns, in new localities, and in manufacturing districts, while in rural districts it increases the death-rate.

The following tables, from the Supplement to the Fifty-fifth Annual Report of the Registrar-General, will serve to illustrate the influence of age and sex-distribution on mortality rates more clearly:—

ENGLAND AND WALES.—MALES AND FEMALES AT ELEVEN GROUPS OF AGES IN A MILLION PERSONS LIVING AT ALL AGES, 1881-90.

Age-periods.	Persons. 1881-90.	Males. 1881-90.	Females. 1881-90.
All ages	1,000,000	485,527	514,473
0–	128,679	64,122	64,557
5–	119,006	59,333	59,673
10–	109,571	54,806	54,765
15–	100,007	49,720	50,287
20–	90,486	42,922	47,564
25–	148,630	71,131	77,499
35–	114,039	55,095	58,944
45–	84,950	40,472	44,478
55–	58,044	27,151	30,893
65–	33,510	15,184	18,326
75 & upwards.	13,078	5,591	7,487

AVERAGE ANNUAL DEATH-RATE PER 1000 LIVING, OF MALES, FEMALES, AND BOTH SEXES, AT TWELVE GROUPS OF AGES, DURING 1881-90.

	All ages.	Under 5 years.	5-	10-	15-	20-	25-	35-	45-	55-	65-	75 and upwards.
Males	20·22	61·69	5·34	2·94	4·30	5·71	7·73	12·35	19·28	34·66	70·17	162·18
Females	18·01	51·99	5·25	3·09	4·40	5·51	7·34	10·55	15·04	28·40	60·08	147·32
Persons	19·08	56·82	5·29	3·02	4·35	5·61	7·53	11·42	17·06	31·33	64·65	153·67

From these figures it will be at once seen that in making any just comparisons between the death-rates of different populations, corrections must be made for age and sex-distribution, although the former exercises the far greater influence of the two. The methods adopted by the Registrar-General for making these necessary corrections may be briefly described as follows:—The mean annual death-rate for England and Wales, for each sex at each of the eleven age-periods during the last decennium, is multiplied by the number of each sex living at each age-period in the town or district under consideration as enumerated in the last census. The series of figures thus obtained, when divided by 1000, gives the calculated number of deaths of each sex for each sex-period. In this way the total number of calculated deaths for each town or district is obtained, and this total, multiplied by 1000 and divided by the total population as recorded in the last census, gives the *standard death-rate* per 1000 for such town or district. Having thus ascertained the standard death-rate for any particular town or district, the next step is to determine the ratio which this bears to the mean average death-rate for the whole of England and Wales during the last decennium, by which a factor is obtained, known as the *factor for correction.* This factor is obviously above or below unity according to whether the standard death-rate is above or below the average general death-rate of England and Wales, and when multiplied by the recorded death-rate of any year gives the

corrected death-rate of such town or district for that year. Thus, to take a concrete example—that of Brighton for the year 1887. The total number of deaths, calculated as above, in respect to Brighton for that year was 2221·34, and the total population, as enumerated in the census immediately preceding, namely 1881, was 107,546, therefore

$$\frac{2221{\cdot}34}{107{,}546} \times 1000 = 20{\cdot}66 \text{ per } 1000,$$

which represents the *standard death-rate* of Brighton for 1887. Now, as the average death-rate for the whole of England and Wales during the previous decennium (1871-80) was 21·27, and the standard death-rate of Brighton having been lower, it must be raised in the same proportion to bring it into comparison with the average annual death-rate of England and Wales. In other words it must be increased by the ratio of 20·66 to 21·27, and this ratio is $\frac{21{\cdot}27}{20{\cdot}66} = 1{\cdot}0296$, which is the *factor for correction.* As the recorded death-rate of Brighton for 1887 was 16·88, therefore $16{\cdot}88 \times 1{\cdot}0296$ gives 17·38, which was the corrected death-rate for that year (Newsholme's *Vital Statistics*).

In almost all large towns the factor for correction is above unity, owing to the excessive proportions of persons at ages of low mortality, while in rural districts it is below unity, owing to the excessive proportions of children and old people having a high mortality.

What is called the *comparative mortality figure* is obtained by dividing the corrected local death-rate by the death-rate of the whole country for any given year and multiplying by 1000, and merely signifies that the same number of persons which give 1000 deaths in England and Wales would give so many deaths in the town or district in question.

The following excerpt from the Registrar-General's table for 1894, applying to the thirty-three great towns, will illustrate more fully the method of correcting recorded death-rates, as well as the significance of the comparative mortality figure.

Towns.	Standard Death-rate.	Factor for Correction for Sex and Age Distribution.	Recorded Death-rate, 1894.	Corrected Death-rate, 1894.	Comparative Mortality Figure, 1894.
England and Wales .	19·15	1·0000	16·59	16·59	1000
Blackburn . . .	17·05	1·1231	17·89	20·09	1211
Croydon . . .	18·37	1·0424	13·19	13·75	829
Portsmouth . .	18·73	1·0224	15·15	15·49	934
Leicester . . .	17·64	1·0855	14·65	15·90	958
Derby . . .	17·36	1·1031	15·01	16·56	998
Brighton . . .	18·94	1·0110	16·41	16·59	1000

It will be seen from the above table that the recorded, or crude, death-rate for the whole of England and Wales in 1894 was 16·59, and that the recorded death-rate of Blackburn was 17·89. It is also seen that the factor for correction given for Blackburn is 1·1231. Then $17{\cdot}809 \times 1{\cdot}1231 = 20{\cdot}09$ which is the corrected death-rate for Blackburn, and $\frac{20{\cdot}09}{16{\cdot}59} \times 1000 = 1211$, which is the comparative mortality figure; or, in other words, the same number of persons that gave 1000 deaths in England and Wales in 1894, gave 1211 deaths in Blackburn.

In calculating the death-rate at various groups of ages for any given year of an intercensal period it is necessary to estimate the population of these groups, and the number of deaths occurring in each group. For the population at all ages the same rate of increase at each group of ages is assumed to continue as in the previous intercensal period.

(5) *Influence of Occupation in Mortality.*—Although there are many difficulties attending generalisations based on the statistics applying to the varied and intricate conditions of industrial life, the principal circumstances which operate injuriously on health have long been established beyond dispute, such as the impure air of badly ventilated or overcrowded work-rooms, air vitiated by gases or vapours, or by metallic, mineral, or organic dust; and exposure to extremes of temperature or bad weather. All these conditions, however, are liable to be obscured, in greater or less degree, by the rate of wages, the housing of the employed, the tempta-

tions to or prevalence of alcoholic abuse, and the physique of the various classes of workers. For example, many of the occupations demanding more than average muscular strength can only be pursued by picked men, while the weakly drift into light indoor work. Then, again, in the earlier periods of life the effect of occupation is not fully developed, while as old age advances statistical results become affected by the retirement from industries of such men as have become physically unable to pursue their employment. For this reason, Dr. Farr selected the period of life between twenty-five and sixty-five years as that in which the influence of occupation is most felt, and in the supplement to the Forty-fifth Report, his successor Dr. Ogle adopted the same view, and published in tabular forms the comparative mortality of numerous occupations based on the statistical returns of 1881-82-83. The present holder of the office of Superintendent Registrar, Dr. Tatham, in the Supplement to the Fifty-fifth Report, has still further elucidated the relations of occupations to mortality which he has based on the returns for the years 1890-91-92. As the statistics applying to the unoccupied embrace all who are physically unfit for occupation, such as a large portion of the insane in lunatic asylums, the inferences which may be drawn from them are of doubtful value, but Dr. Tatham, after pointing out the disturbing factors, shows that between twenty-five and sixty-five years of age the comparative mortality figures of occupied and unoccupied males are 953 and 2215 respectively, or in other words that the number of males included in this definite age constitution that would give 1000 deaths among the general population, and 679 deaths in the healthy districts, would give 953 deaths among occupied, and 2215 among unoccupied males. Nearly two-thirds of this enormous excess is shown to be due either to disease of the nervous system or to phthisis, largely accounted for by the deaths from these diseases occurring among the insane; while the mortality attributed to cancer is more than double, and that attributed to alcoholism together with liver disease, to diseases of the urinary system, and to suicide, is about

double as heavy among the unoccupied as it is among the occupied class. As age advances, however, the unoccupied class contains a diminishing proportion of unsound lives; and at ages over sixty-five, the mortality of unoccupied males exceeds that of occupied males by only 3 per cent.

Dealing with all occupied males aged twenty-five to sixty-five years, and taking their mortality as 100, Dr. Tatham in the following table shows the mortality from certain specified diseases in London, industrial districts, and agricultural districts:—

	All Occupied Males.	Occupied Males. London.	Occupied Males. Industrial Districts.	Occupied Males. Agricultural Districts.
All Causes	100	120	131	72
Influenza	100	100	100	100
Alcoholism	100	138	146	54
Rheumatic Fever	100	100	114	86
Gout	100	300	100	100
Cancer	100	134	109	91
Phthisis	100	150	121	73
Diabetes	100	114	100	100
Diseases of Nervous System	100	107	132	77
,, Circulatory ,,	100	107	122	75
,, Respiratory ,,	100	124	166	51
,, the Liver	100	111	119	89
Other Diseases of Digestive System	100	100	129	82
Diseases of Urinary System	100	137	122	78
Accident	100	86	105	79
Suicide	100	129	114	86
Other Causes	100	91	130	76

"In the industrial districts not one of these causes of death, and, in London only two, fall below the average. In the agricultural districts not one rises above the average. In London the proportional excess from alcoholism, gout, cancer, phthisis, diseases of the respiratory and urinary systems, and from suicide is greater than that from all causes. In the industrial districts the excess of general mortality is exceeded only by that of alcoholism and by that of diseases of the nervous and respiratory systems. In the agricultural districts alcoholism and diseases of the

respiratory system are barely more than half as fatal as they are among all occupied males, while phthisis is 27 per cent below that standard; the mortality from all causes showing, as already stated, an advantage amounting to 28 per cent."

In comparing the mortality from all causes of some of the larger number of occupations investigated, it may here be explained that Dr. Tatham's comparative mortality figures were calculated as follows:—He first found that on the average of the three years 1890-91-92, 1000 deaths occurred annually among 61,215 males between twenty-five and sixty-five years of age, and 61,215 therefore formed "the standard population" on which the figures were based. This number was divided into the four decennial age-groups embraced within that age limit as determined by the census of 1891. From the 1891 census, occupations were then abstracted in such decennial groups, and by applying to the numbers in each group the corresponding rates of mortality for any occupation, the number of deaths was ascertained which would occur among 61,215 men engaged in that occupation, but with the same age constitution as that which ruled in the general population.

This method of arriving at the comparative mortality figure in respect to each occupation, Dr. Tatham illustrates by the following table applying to the clergy:—

Age.	Number Living.	All Males.		Clerical Profession.	
		Rate of Mortality per 1000.	Deaths.	Rate of Mortality per 1000.	Deaths.
25–35	22,586	7·67	173	4·23	96
35–45	17,418	13·01	227	5·18	90
45–55	12,885	21·37	275	10·52	136
55–65	8,326	39·01	325	25·35	211
25–65	61,215	...	1000	...	533

It is thus seen that within the limits of age under

consideration, the true ratio of the mortality of clergymen to that of males generally is as 533 to 1000, and this is expressed by terming 533 the "comparative mortality figure" for clergymen. In none of the large number of occupations dealt with is this figure so low, though the mortality figures of gardeners and farmers are not much higher, being 553 and 563 respectively. For the legal profession, the mortality figure is 821, and for the medical profession it rises to 966. In all three professions, diseases of the heart are the most frequent of all causes of death; phthisis and diseases of the respiratory system generally occupying less important places in the list of fatal diseases; whereas in most other occupations it is these latter diseases or one of them, which stand higher than any others in the scale of mortality. Compared with the male population, the clergy experience more than double, and the legal profession four times, the average mortality from diabetes; while the special liability of medical men to gout, diabetes, urinary diseases and suicide is affirmed quite as plainly by Dr. Tatham's figures as by those prepared by Dr. Ogle relating to the profession. Indeed, the tendency to suicide, has notably increased since the earlier period, although the mortality definitely ascribed to alcoholism has fallen to about the same level as that of the general population.

The comparative mortality figure for teachers is 604; of artists and architects, 778; and of commercial clerks, 915; while of innkeepers, wine-merchants and publicans, it is 1642; and of inn and hotel servants, it is as high as 1725. These excessive ratios in the liquor trades are due directly or indirectly to alcoholic abuse, and in a special table Dr. Tatham shows that publicans, without distinction of locality, die 7 times as fast as do occupied males from alcoholism; $6\frac{1}{2}$ times as fast from diseases of the liver; 6 times as fast from gout; and more than double as fast from diseases of the urinary system, from rheumatic fever, from diabetes, and from suicide. As shown in another table, brewers and butchers stand next in the list in their mortality from alcoholism and diseases of the liver together,—

the former being $2\frac{1}{2}$ times, and the latter $2\frac{1}{4}$ times as high as the standard; then follow chimney-sweeps and dock labourers with a mortality from these diseases about double the standard. Dr. Tatham further asserts that diseases of the respiratory system cause heavy mortality among most of the classes of men who are addicted to the excessive use of alcohol; but the general tendency of the figures is to suggest that special liability to these diseases is caused by exposure to wet and cold, and that such exposure is followed by fatal results more often among intemperate than among temperate men. Commercial travellers also succumb in undue proportion to alcoholism and diseases of the liver, and die almost as fast again as the average from diabetes, as well as suffering exceptionally from Bright's disease.

In dealing with the effects of dust-laden air in industrial occupations, Dr. Tatham has selected the men engaged in agricultural pursuits in preference to fishermen, who were selected by Dr. Ogle as typical of a healthy occupation, mainly on account of the unstable composition of the fishermen tribe, which Dr. Ogle himself was careful to point out. Besides, they constitute a much larger population on which to base statistical results, and like fishermen are a healthy body of men who spend the greater part of their lives in the open air.

While laying stress upon the disturbing influence of influenza, which affected in varying degrees all the comparisons between the periods dealt with by Dr. Ogle and Dr. Tatham, because the disease prevailed exceptionally throughout the more recent period, the following table, selected from Dr. Tatham's tables, is highly instructive as illustrating the enormous waste of life which, although largely preventable, is still sustained by the workers in several important industries. Although it is not suggested that the whole of the difference between the mortality from phthisis and diseases of the respiratory system which prevailed among those employed in dust-producing occupations, and that of agriculturists, is due to the presence of dust or other irritating substances in the air breathed, the table demonstrates very

clearly that this operates as a most important factor, though in varying degrees, in all of them.

Occupation.	Phthisis and Diseases of the Respiratory System.		Phthisis.	Diseases of Respiratory System.	Diseases of Circulatory System.
	Mortality Figure.	Ratio.	Mortality Figure.		
Agriculturist . . .	**221**	**100**	**106**	**115**	**83**
Ironstone Miner . . .	294	133	90	204	84
Carpenter	326	148	172	154	106
Coal-miner	366	166	97	269	120
Corn Miller . . .	366	166	143	223	112
Baker, confectioner . .	392	177	185	207	130
Blacksmith . . .	392	177	159	233	136
Locksmith	428	194	223	205	104
Wool manufacture . .	447	202	191	256	131
Tin worker . . .	451	204	217	234	124
Carpet Rug Manufacturer .	471	213	226	245	87
Bricklayer, mason, builder .	476	215	225	251	130
Rope Maker . . .	486	220	219	267	118
Cooper, wood-turner . .	526	238	250	276	137
Cotton manufacture . .	540	244	202	338	152
Lead worker . . .	545	247	148	397	272
Chimney-sweep . . .	551	249	260	291	142
Brass worker . . .	552	250	279	273	126
Stone quarrier . . .	576	261	269	307	137
Zinc worker . . .	587	266	240	347	126
Iron and steel manufacture	645	292	195	450	162
Gunsmith	649	294	324	325	153
Copper miner . . .	678	307	331	347	121
Copper worker . . .	700	317	294	406	186
Lead miner . . .	705	319	380	325	142
Glass manufacture . .	740	335	295	445	157
File maker	825	373	402	423	204
Tin miner	885	400	508	377	95
Cutler, scissors maker .	900	407	382	518	167
Potter, earthenware manufacturer	1001	453	333	668	227

It will be seen that the table shows the mortality figures for phthisis and diseases of the respiratory system combined; and also those for phthisis and for diseases of the respiratory and circulatory systems, separately; while in an additional column, the figures for phthisis and respiratory diseases

together are compared,—the mortality among agriculturists being taken as 100, and that among other occupations being taken proportionally to this standard. In commenting on the table Dr. Tatham says: "One is not surprised to find that the combined mortality from phthisis and diseases of the respiratory system is higher in each of the 29 specified occupations than it is among the class of agriculturists; but it is important to observe that the table includes 22 occupations, in each of which the mortality from these diseases is more than double that of agriculturists, and further that these 22 occupations include 8 (giving employment to nearly 102,000 men), in which the mortality from phthisis and respiratory diseases together ranges from three to four and a half times that of the agricultural class."

Potters sustain a mortality from phthisis and respiratory disease far in excess of that of any other group in the list. Tin-miners suffer from phthisis alone a mortality nearly five times greater than agriculturists, and appear to die more rapidly from this disease than farmers in agricultural districts die from all causes together. File-cutters, cutlers, and lead-miners also suffer inordinately from phthisis, while from lung diseases, other than phthisis, potters suffer more severely than do any other workers on the list. Cutlers, iron and steel workers, glass-makers, and file-cutters also suffer excessively from respiratory diseases. Dr. Ogle, in summarising his remarks concerning the effects of dust on the lungs in 1880-81-82, pointed out that the dust of coal, and that of the varieties of wood which are used by carpenters, appeared to be the least injurious, whilst the dust of metals and of stone appeared to be the most injurious kinds of dust (see *ante*, p. 100). Dr. Tatham's figures on the whole confirm this generalisation, and though Dr. Ogle's list was not so extensive, the occupations dealt with appear nearly in the same order as to mortality from phthisis and lung diseases, as those in 1890-91-92.

In another table dealing with the effects of breathing foul air, it is shown that printers, bookbinders, and musicians sustain a mortality from phthisis which is more than

three times that of the agricultural class; while in respect to phthisis and respiratory diseases combined, in addition to these three, hatters, hairdressers, tailors, workers in the tobacco trade, drapers, shoemakers, all suffer excessively. In a third table, it is shown that the occupations which are specially exposed to the risks of plumbism, such as lead-workers, file-makers, plumbers, painters and glaziers, potters, glass-makers, etc., are associated with increased liability to disorders of the urinary and nervous system, and that this liability increases with the mortality from plumbism. In some of the occupations, such as those of plumbers, painters and glaziers, and glass-makers, there is evidence of unusual mortality from gout. Very probably, however, this is in some measure due to temptations and inducements to alcoholic excess.

But without discussing this subject further, it may be said that in this Fifty-fifth Supplement to the Registrar-General's Report (Part II.) Dr. Tatham has presented in tabular form a mass of evidence respecting occupational mortality which hitherto has never been attempted on the same extensive scale, and that in this respect his elaborate commentary on the statistical results is the most reliable and valuable contribution to the etiology of industrial diseases which has ever appeared.

In addition to influencing the general death-rates of localities, sex has a very important bearing upon the mortality from certain diseases, owing partly to differences in constitution, and partly to exposure to conditions favourable to the development of these diseases. For example, among females there is a higher mortality from phthisis from 5 to 25 years than there is among males, and from digestive diseases, from 20 to 45 years. There is also a higher mortality among females over 10 years from scarlatina, owing probably to the greater exposure to infection. In respect to age, again, there is a still more marked relation to mortality from certain diseases applying to both sexes. For instance, the maximum mortality from small-pox, among the unvaccinated, whooping-cough, and diarrhœa

occurs in the first year of life; from measles in the second; from scarlet fever in the third; and from diphtheria in the fourth. Phthisis is at its minimum from the fifth to the tenth year, when it increases up to the forty-fifth year and then diminishes. Cancer mortality is insignificant in the earlier years, but increases rapidly from about the twenty-fifth year to the close of life.

(6) *Mortality in relation to density of population.*— In a preceding table (see p. 571), it is shown that the crude death-rate in the 28 chief towns of England during 1880-90 was 21·5 per 1000; in the 59 smaller towns, 19·7; while in the rural districts it did not exceed 17·6 per 1000. Although density and mortality may therefore still be said to increase or decrease together, in a general sense, the late Dr. Farr's formula that the mortality increases with the twelfth root of the density, or any similar formula, is of no statistical value, because the relation between them has become too complex to admit of definite comparison. It may be said, however, that the mortality in all the crowded parts of large towns is much higher at nearly all ages, and especially during childhood, adolescence, and the productive period of life, than in the better circumstanced and more salubrious suburbs. And this excessive mortality is perhaps attributable in far greater degree to undue overcrowding than to mere aggregation of dwellings, though the two are generally associated. Thus, Dr. Russell, Medical Officer of Glasgow, in an address delivered to the Glasgow Philosophical Society in November 1888, has demonstrated most strikingly the connection between the size of the average house and the general death-rate. Of eight great Scotch towns, Aberdeen, with 13·6 per cent of its population living in one room, presented the lowest death-rate, the death-rate rising *pari passu* with the diminution in size of the ordinary house, until Glasgow, with 24·7 per cent of its population living in one room, exhibited the highest death-rate. These one- and two-room houses are commonly "made-down houses," *i.e.* parts of houses of larger size which are now let separately, and, in some cases,

single rooms are divided by wooden partitions, and let to two separate families.

On comparing the death-rates of these various classes of the population it was found that the death-rate among those living in one or two rooms was 27·74 per 1000; among those living in houses of three and four rooms it was 19·45 per 1000; while among those living in houses of five rooms and upwards it was only 11·23 per 1000.

Similar evidence was adduced by Dr. Barry and Mr. Gordon Smith in their report to the Local Government Board in 1880 on the effects of overcrowding in back-to-back houses, but there is no doubt that poverty, drink, neglect in nursing infants, congenital debility, filth,—all contribute to the mortality in greater degree than mere density of population.

(7) *Mortality in relation to Seasons.*—In estimating the significance of statistical results, no correct inferences can be drawn unless due attention is paid to the important influence of weather changes. Generally speaking, it may be said that during winter there is a predisposition to diseases of the respiratory organs, and that any fall below the mean average temperature is followed by an increased sick-rate and death-rate from these diseases. During summer, on the other hand, intestinal disorders become more prevalent, and any rise above the mean average temperature will be followed by an increased sick-rate and death-rate from diarrhœa and filth diseases generally. As a rule, the mortality is highest in the first quarter of the year and lowest in the third,—the order from highest to lowest being first, fourth, second, third,—but in many districts this sequence is found to vary considerably, and indeed, it is occasionally found to vary in respect to the country generally.

Apart from the influence of season, there are certain factors which appear to operate in determining cyclical changes, more especially in respect to diseases of an infectious character, and regulate to a certain extent their periodicity. One of these factors, and that probably the

most potent, is the influence of an accumulation of susceptible persons in the intervals between two epidemics of the same disease. The other factors have been vaguely classed under the term "pandemic influence," which, after all, means nothing more than the propagation of disease among susceptible persons through the agency of infection, and which may be often intensified by meteorological or telluric conditions.

4. *Sickness Rates.*—In the absence of any complete system of registration of cases of disease, it becomes a matter of extreme difficulty to estimate the amount of sickness which may be prevalent in any district during any stated time. Hitherto such estimates have been based mainly on the records of benefit societies, sick-clubs, army, navy, and police, and they apply solely to disabling sickness occurring amongst men between the ages of 15 and 65. From such records of sick-time, Dr. Farr, in his Supplement to the Thirty-Fifth Report of the Registrar-General, estimated that to one annual death in a body of men, two men are constantly suffering from sickness of some severity, or, in other words, that to every death there are two years of severe sickness. In the police and some friendly societies the constantly sick to every death which occurs are 2·8, while in the army at home the ratio was at one time 4·2, the difference being due to the prevalence of enthetic disease.

According to Mr. Sutton, the actuary to the Registry of Friendly Societies, the average number of days' sickness per member while in receipt of sick-pay is very nearly $1\frac{1}{2}$ weeks per annum. On the basis of these data and Dr. Farr's estimate, it may be assumed that as in 1890 there were 564,248 deaths in England and Wales, there were 1,028,496 constant sufferers from severe sickness, and nearly two million sufferers from such illness as would require medical relief, or throw the members of Friendly Societies on their clubs. It need hardly be said that the amount of sickness represented by these figures implies an immense pecuniary loss to the State. The more recent estimates based on returns since 1890 show an increase in the sick-rate, due to the prevalence of influenza.

With regard to diseases which, as a rule, occur only once during a lifetime, such as scarlatina, small-pox, and some of the other zymotic diseases, an approximate estimate of the number of cases occurring in a district can sometimes be made from the number of deaths. Thus the mortality occurring among cases of scarlatina admitted into hospitals has been taken as a basis for calculating the number of cases in any district from the deaths registered in such district, and the ratio estimated in this way has been given as about ten cases for every death. But such estimates are comparatively valueless, because, apart from the incompleteness of the data on which they are based, the mortality will vary very much according to the severity of the epidemic. Far more reliable statistics will doubtless be obtained after an extended experience of the registration of cases of infectious disease in towns and districts where the Infectious Diseases (Notification) Act is in force.

Section IV.—Longevity and Life-Tables

1. The term longevity is used to embrace various statistical expressions, such as—

(1) The mean age at death.

(2) The probable duration of life.

(3) The mean duration of life.

(4) The expectation of life, or mean after-lifetime.

(1) The *mean age at death* of a population is obtained by dividing the sum total of the ages at death by the number of deaths. It is a very fallacious indication of longevity, and affords no true test of sanitary condition, because it fluctuates very largely according to the varying proportions of young and old lives in different districts. In districts where the birth-rate is high the mean age at death will be comparatively low. The mean age at death of an entire generation alone gives accurately the mean duration of life, and this is determined by life-tables. According to Dr. Farr's life-table, which was based upon the census and mortality returns 1838-54, the mean age at death of an

English generation was 40·86 years. But inasmuch as the population of England is not stationary but always rapidly increasing, the mean age at death of all who died during the years 1838-54 was 29·4 instead of 40·86.

(2) What is called the *probable duration of life*, or *vie probable* of French writers, is the term used to signify the age at which any number of children born into the world will be reduced to one-half, so that there are equal chances of their dying before and after that age. It can only be ascertained from a life-table, and is of little value as a test of longevity. Out of a million children born in England and Wales the males become reduced to one-half their number before they reach their forty-seventh year, and the females lose half their number by the fifty-second year.

(3) The *mean duration of life*, or *vie moyenne*.—When a population is stationary, that is, when its age and sex-constitution do not alter, the mean duration of life is identical with the mean age at death. When the population is not stationary, or, in other words, is increasing by excess of births over deaths, by immigration, or by both these causes, the mean duration of life has the same signification as the mean after-lifetime.

(4) The *expectation of life* at any age is the average number of years which a person at that age will live, as shown by a life-table. The expectation of life at birth is synonymous with the mean duration of life, but at any age after birth it represents the *mean after-lifetime*. As applied to communities, it is the mean lifetime of a generation of persons traced by the life-table method from birth to death, and is the only true test of the health of populations.

The mean age at death, or expectation of life after birth, in an increasing population has been approximately calculated by the following formulæ :—

a. According to Dr. Farr, if X = expectation of life at birth, b = birth-rate per unit of population, and d = death-rate per unit, then $X = (\frac{1}{3} \times \frac{1}{b}) + (\frac{2}{3} \times \frac{1}{d})$.

For example, the average birth-rate during the ten years 1871-80 was 35·35 per 1000 = ·03545 per unit of popu-

lation, and the death-rate was 21·4 per 1000 = ·0214 per unit, then $X = (\frac{1}{3} \times \frac{1}{\cdot 03545}) + (\frac{2}{3} \times \frac{1}{\cdot 0214}) = 40{\cdot}31$ years. This is somewhat below the actual estimate, for according to Dr. Ogle's life-table for the corresponding period, the mean duration of life for males was 41·35 years, and for females 44·62 years.

b. In Dr. Bristowe's formula, which assumes that the birth-rate and death-rate continue uniform from year to year, that there is no immigration or emigration, and that all the inhabitants die at the same age, $X = \frac{\log. b - \log. d}{\log. (1+r)}$, where b = birth-rate per unit, d = death-rate per unit, and r = its annual increase = $b - d$.

c. For ages between 25 and 75 the formula of Willich gives fairly approximate results. According to this, if X = expectation of life, and a = present age, then $X = \frac{2}{3}(80 - a)$. Thus, at the age of 50, the expectation of life would be $\frac{2}{3}(80 - 50) = 20$, and, according to Dr. Tatham's life-table, it is 18·8 for males, and 20·5 for females.

It should be observed here that these formulæ were based upon the statistics of more than a quarter of a century ago, and that with improved conditions of life they can no longer be depended on for yielding even approximately accurate results.

2. *Life-Tables.*—According to Dr. Farr, a life-table is a biometer which indicates the exact measure of the duration of life under given circumstances, and is as indispensable in gauging the influence of sanitary or insanitary conditions as the barometer or thermometer and other instruments are in physical research.

In constructing a life-table, the two essentials are the number and ages of the living, and the number and ages of the dying. The former are obtained from a census population, in which the distribution according to ages and sexes is known, and the latter from the returns of deaths grouped as regards age and sex in the same way as the census population. In order, however, to ensure as great accuracy as possible, it is advisable to take the death-returns of a whole intercensal period, and the mean population. Thus,

Dr. Tatham's extended Life-Table was based on the mean population of the decennium 1881-90, and the deaths during the same period.

By making the births the basis of a life-table, the decrement in the first year will be represented by the infant mortality. Thus we will assume that in starting with a hypothetical generation of 100,000, the rate of infant mortality is 150 per 1000 births, then at the end of the first year the number will be reduced to 85,000, because that rate of infant mortality represents 15,000 deaths. In order to find the number of survivors at the close of the second year, it is necessary to use a special formula which is based upon the rate of mortality of the mean population living during the second year. Thus, we will suppose that M represents the death-rate per 1000 living at that age. Now these M deaths per 1000 living are supposed to be evenly distributed over the whole of the year, so that $\frac{1}{2}$M will occur in the first half of the year, and $\frac{1}{2}$M in the second half. Hence the 1000 persons may be regarded as decreasing from $1000 + \frac{1}{2}$M at the beginning of the year, to $1000 - \frac{1}{2}$M at the close of the year, and the ratio of the final to the initial population is $\frac{1000 - \frac{1}{2}\,M}{1000 + \frac{1}{2}\,M}$. Or if we take m as the death-rate per unit of the population during the second year of life, the ratio of those surviving at the close of the second year to those surviving at the close of the first year would be $\frac{1 - \frac{1}{2}m}{1 + \frac{1}{2}m}$, and this formula represents the chance which each unit of the population has of living to the end of the second year. Whichever formula is used the result will be found to be the same. Thus, we will suppose that the death-rate during the second year is 65 per 1000 living at that age. Then M = 65, and m, the mortality per unit, = ·065.

Now

$$\frac{1000 - \frac{1}{2}\,M}{1000 + \frac{1}{2}\,M} = \frac{2000 - M}{2000 + M} = \frac{2000 - 65}{2000 + 65} = \frac{1935}{2065}$$

and

$$\frac{1 - \frac{1}{2}m}{1 + \frac{1}{2}m} = \frac{2 - m}{2 + m} = \frac{2 - ·065}{2 + ·065} = \frac{1·935}{2·065}.$$

It is evident that these two fractions are of equal value, so that in this instance the fraction $\frac{1935}{2065} = \cdot 93704$ represents the chance which each unit of the population has of living to the close of the second year. If, then, 85,000 are alive at the beginning of the second year, this number would be reduced to 79,648 at its close, because

$$2065 : 1935 : : 85{,}000 : 79{,}648 ;$$

or

$$85{,}000 \times \cdot 93704 = 79{,}648.$$

Similarly, the numbers of survivors at the close of each year down to five may be calculated. After the fifth year it is usual to proceed in group-periods of five years up to twenty-five, and afterwards in decennial periods, until the whole generation becomes extinct. But the formula used is substantially the same throughout, with this difference, that given the death-rate of a group of ages, that rate is assumed to hold good for each year included in the group. Thus, let it be assumed in this instance that m_1 represents the death-rate per unit of the population living between five and ten years of age, then $\frac{2-m_1}{2+m_1}$ becomes the formula representing the chance of surviving to the close of each year, and therefore $(\frac{2-m_1}{2+m_1})^5$ will represent the probability (p) of living to the close of the tenth year. If, now, P represents the number surviving at the end of five years, the number left at the end of ten years will be $P \times (\frac{2-m_1}{2+m_1})^5$, and so on until the twenty-fifth year is reached. The next age-period, twenty-five to thirty-five, is a decennial period, and therefore if P_1 represents the number surviving at the beginning of that period, and μ_2 the death-rate per unit for that period, the number left at the close of the thirty-fifth year will be $P^1 \times (\frac{2-\mu_2}{2+\mu_2})^{10}$, and so on till the whole generation becomes extinct.

It need hardly be said, in passing, that all these calculations are carried out by means of logarithm tables.

The series of figures thus obtained constitutes what is

called the l column of a life-table, and represents the number born and living at each age or group of ages, or, in other words, it represents the number surviving at certain points of time, and thus renders it possible to calculate the expectation of life at any age represented in the table. A life-table for gauging sanitary condition assumes a stationary population, recruited annually by the same number of births, male and female, as are found to exist in the general population, and traces the history of a hypothetical generation through life under all the influences and circumstances which attend each year or group of years during the era under examination.

Thus, in the following table (see Newsholme's *Vital Statistics*), abridged from Dr. Farr's Life-Table No. 3, the table starts with a hypothetical generation of 1,000,000 persons, of which 511,745 are males.

DR. FARR'S ENGLISH LIFE-TABLE (3) FOR MALES

1 Age or Age-Period. x.	2 Annual Mortality per Unit at Age x. D or M_x.	3 Probability of Living one Year from each Age. p_x.	4 Number Born and Living at each Age. l_x.	5 Mean Population in each Year of Age. P_x.	6 Years of Life Lived at Age x and upwards. Q_x.	7 Mean After Lifetime a each Age x E_x.
0	0·18326	0·83212	511,745	456,820	20,426,138	39·91
5	0·01369	0·98640	370,358	367,672	18,410,252	49·71
10	0·00563	0·99438	353,031	352,007	16,608,936	47·01
15	0·00519	0·99482	344,290	343,415	14,866,429	43·18
20	0·00832	0·99171	333,608	332,231	13,169,656	39·48
25	0·00920	0·99084	319,442	317,892	11,536,677	36·12
35	0·01105	0·98901	288,850	287,229	8,492,601	29·40
45	0·01554	0·98458	253,708	251,763	5,774,489	22·76
55	0·02485	0·97644	209,539	206,984	3,447,708	16·45
65	0·04698	0·95410	150,754	147,315	1,631,508	10·82
75	0·10391	0·90122	75,777	72,012	491,685	6·49
85	0·21966	0·80208	16,877	15,151	63,030	3·73
95	0·42035	0·65265	833	678	1,806	2·17
105	...	...	4	3	5	...

It is seen from the above that an ideal life-table consists of a series of columns, in the first of which is entered the various years of life or age-periods, and this is headed by the symbol x. The second column is marked D or the

M_x column, and the entries in it, as already shown, are obtained by dividing the deaths during each year or each age-period by the corresponding mean population. The entries in the third, or p_x column, represent the probability of living one year for each age or age-period, and are calculated from the formula $p_x = \frac{2000 - D}{2000 + D}$. The entries in the fourth column represent the number surviving at each successive age, and is therefore called the l_x column. These numbers are obtained by multiplying the number living at the immediately preceding year by p_x.

The next column, called the P_x column, shows the mean number living in each year of life. Thus, in an extended life-table, the mean number living in the twentieth year $= \frac{l_{19} + l_{20}}{2}$.

The sixth, or Q_x column, shows the aggregate number of years which the persons at each age in this table will live; in other words, the number opposite any age x is the sum of all the numbers in this P_x column from that age on to the end of the table, that is, until all the lives become extinct.

The last or E_x column represents the expectation of life, or mean after-lifetime at each age or age-group, and is obtained by the formula $E_x = \frac{Q_x}{l_x}$. Thus, the mean after-lifetime, at any age x is calculated by adding together the years lived through by the whole of the life-table population after that age, and dividing by the number of survivors at that age, $\frac{Q_x}{l_x}$. For example, in the above table the expectation of life, say at 45, may be ascertained as follows:—Add together the figures in column (4) (l_x), below 45. This sum gives the number of complete decennia lived through as 453,784. But in addition to the decennia which he completes, each unit of the population is supposed to live through a certain portion of the decennium on which he enters, and this, on the basis of the hypothesis stated at the outset, is estimated to be one-half a decennium. Therefore the 253,708 survivors at 45 are assumed to live through 253,708 half decennia, or 126,854 decennia, in

addition to the 453,784 decennia which have to be shared amongst them. This makes a total of 580,638 decennia, or 5,806,380 years, and this total, divided by the number surviving at the age of 45, gives 22·88 years as the expectation of life at that age, which, as seen from the table, is only ·12 in excess of the actual expectation of life calculated by Dr. Farr's extended life-table.

According to Dr. Farr, the expectation of life, by the short-method table, is nearly the same up to 15 years as by the English table; at ages from 25 to 65 the differences range from ·37 to ·53 of a year, the short method giving an excess; and after that age there is a rapid increase in the mean after-lifetime by the short-method table. (See *Supplement to the Thirty-fifth Annual Report* of the Registrar-General.)

By means of these short life-tables Dr. Farr was able to show that the expectation of life in rural Surrey in 1841 was 45 years, in the Metropolis 37 years, and in Liverpool only 26 years.

Local life-tables have been constructed for London (Shirley), Manchester (Tatham), Glasgow (Russell), and Brighton (Newsholme), based on the statistics of 1881-90, which show that at each age, and for each sex, the expectation of life in London exceeds that in Manchester and Glasgow, but is less than that in Brighton. Such life-tables can, of course, be constructed for any town, county, or district, provided the necessary facts are obtainable, and they are of the utmost value in gauging the gain or loss of life occurring in each age-group, as indicated by the fluctuations of mortality in a given period.

In Dr. Farr's three national tables, based on the returns of the entire kingdom, there is observable a remarkable uniformity in the expectation of life at all ages from 1838 to 1854, and, indeed, in spite of annual fluctuations, the mortality remained almost stationary up till 1871. The English Life-Table, however, prepared by Dr. Ogle, and published in the *Supplement to the Forty-fifth Annual Report* of the Registrar-General, exhibits the effects which

improved sanitation was already beginning to produce on the expectation of life at different ages, and more especially in the earlier periods, and these effects are still more pronounced in Dr. Tatham's new Life-Table for 1881-90, published in the *Supplement to the Fifty-fifth Annual Report.* This is shown in the following abridged table :—

Mean After-Lifetime (*Expectation of Life at various Ages*) *from Life-Tables based upon English Mortality in* 1838-54 (Farr), 1871-80 (Ogle), *and* 1881-90 (Tatham).

Ages.	Males.			Females.		
	1838-54.	1871-80.	1881-90.	1838-54.	1871-80.	1881-90.
0 . . .	39·91	41·35	43·66	41·85	44·62	47·18
5 . . .	49·71	50·87	52·75	50·33	53·08	54·92
10 . . .	47·05	47·60	49·80	47·67	49·76	51·10
15 . . .	43·18	43·41	44·47	43·90	45·63	46·55
20 . . .	39·48	39·40	40·27	40·29	41·66	42·42
25 . . .	36·12	35·68	36·28	37·04	37·98	38·50
35 . . .	29·40	28·64	28·91	30·59	30·90	31·16
45 . . .	22·76	22·07	22·06	24·06	24·06	24·05
55 . . .	16·45	15·95	15·74	17·43	17·33	17·23
65 . . .	10·82	10·55	10·31	11·51	11·42	11·26
75 . . .	6·49	6·34	6·10	6·93	6·87	6·68
85 and upwards.	3·73	3·56	3·29	3·98	3·88	3·71

It will be seen from the above that in all three tables the expectation of life of females is higher than that of males. It is also seen that a male, exposed throughout life to the rate of mortality obtaining in England and Wales in 1881-90 would on the average live 2·31 years longer than he would have lived had he been subject to the rates prevalent in 1871-80, and 3·75 years longer than he would have lived had he been subject to the rates prevalent in 1838-54. According to the fully detailed figures of the three English Life-Tables, the 1881-90 Life-Table shows improved expectations of life, compared with those in the earlier tables, up to twenty-six years of age; from age twenty-seven until age forty-four, the expectations are

lower than those in the first table, but higher than those in the 1871-80 table; for ages forty-five and upwards, the expectations of life are lower by the new table than by either of the other two.

Except during early childhood, the expectation of life decreases as age advances. The increase of the expectation in passing from infancy to childhood indicates special risks of mortality during that period, and the survivors thereby gain improved chances of future lifetime. Even under the most favourable circumstances, the mortality among infants is very high, and hence it is that the only example which the life-tables present of an expectation of life increasing as age advances is in the case of young children. From birth onwards, the expectation of life increases up to the age of about four years in least-favoured localities, to about two in selected healthy districts, and afterwards decreases year by year through the remainder of life. But, as Dr. Tatham puts it, "the better the health conditions represented by the life-table are, the less is the increase of the expectation, the sooner is the age of maximum expectation attained, and the sooner also is the age reached at which the expectation falls below that of birth." These points are illustrated by the following table, which Dr. Tatham has drawn up from the English Life-Tables, from the Manchester Life-Table which he prepared for that city, and from his new Table for Selected Healthy Districts:—

	England and Wales.			Manchester Township, 1881-90.	Selected Healthy Districts.	
	1838-54.	1871-80.	1881-90.		1849-53.	1881-90.
	Males.					
Expectation of life at birth .	39·91	41·35	43·66	28·78	48·56	51·48
Age of maximum expectation .	4	4	3	4	3	2
Increase of expectation, from birth to age of maximum. In years	9·90	9·66	9·66	12·02	6·28	6·87
Increase of expectation, from birth to age of maximum. Percent.	24·8	23·4	22·1	41·8	12·9	13·3
Year of life during which the expectation first falls below that at birth . . .	20th	18th	16th	22nd	14th	12th
	Females.					
Expectation of life at birth .	41·85	44·62	47·18	32·67	49·45	54·04
Age of maximum expectation .	4	4	3	4	3	2
Increase of expectation, from birth to age of maximum. In years	8·58	8·58	8·28	11·14	4·96	5·82
Increase of expectation, from birth to age of maximum. Percent.	20·5	19·2	17·6	34·1	10·0	9·8
Year of life during which the expectation first falls below that at birth . . .	18th	17th	15th	21st	12th	10th

It will be observed from this table, for example, that while the expectation of life of males, in selected healthy districts, is nearly eight years higher at birth than in the last English Life-Table, and over ten years higher than in the first table, the maximum expectation age was reached at two years of age instead of three, by which time it had received an increment of 13·3 per cent only of the expectation at birth. After two years of age, the expectation decreased, and fell below its original level in the twelfth year of age. Or, if the three English Life-Tables are compared, it is seen that, while the expectation of life begins to fall below that at birth in the sixteenth year in the 1881-90 table, it does not begin to fall till the eighteenth year in the 1871-80 table, nor till the twentieth year is reached in the first table.

By another series of tables, Dr. Tatham shows that, in comparing life-tables of different localities, but for the same period, the advantage of the healthier localities is found to

increase steadily until old age, and that, taken generally, the advantage incidental to healthier periods, as well as localities, is shared by each sex at every age-group. If the fifty years of age between 15 and 65 be taken for comparison, the healthier districts are shown by the Life-Tables of 1881-90 "to have this double advantage: that not only is their average lifetime longer in itself, but a greater portion of it belongs to what may be considered the effective working period of life."

It is sometimes contended that the differences exhibited by the several life-tables, while they furnish the strongest possible evidence of the effects of improved sanitation and better conditions of life as regards food, are only evidence of the interference with the law of survival of the fittest, and with results which are less favourable to the health and vigour of adult life. This contention, however, does not hold good, for though it is true that there is nowadays a much greater saving of life among the weakly than in the earlier periods, the improved conditions prevent many of those being included in the ranks of the weakly who would otherwise have become physically degenerated, and short-lived.

For further information with regard to the construction and value of life-tables, see Farr's *Vital Statistics*, edited by Noel Humphreys; Newsholme's *Vital Statistics;* and the *Supplement to the Fifty-fifth Report* of the Registrar-General, by Dr. Tatham.

Section IV.—Statistical Fallacies

In previous parts of this chapter various instances have been illustrated in which errors as regards statistical results are likely to creep in, *e.g.*—

(1) In estimating the population of a town or district;

(2) In tabulating death-returns;

(3) In drawing conclusions from death-rates for short periods, or from death-rates of small districts;

(4) In taking the average of the death-rates of several

districts of a town or combined district as representing the general death-rate of the whole town or district;

(5) In excluding the deaths occurring in large public institutions whose inmates do not belong to the district, while including the population of such institutions;

(6) In estimating the infant or child mortality as a percentage of the total deaths; and,

(7) In drawing conclusions in respect to birth-rates and death-rates without taking into consideration the age and sex-distribution of the population.

It has already been pointed out that, in tabulating statistics and drawing inferences from them, it is essential that the facts or units should be strictly accurate, and in order to be comparable they should belong to the same category. The dividing character between each group must be precise and definite, so that the characteristics on which any group is formed should be common to each unit included in that group, and should leave no room for doubt under which group or heading every unit should be classified.

Statistics, though generally arranged in tabular form, are often represented graphically. If a square or rectangular space is divided by vertical and horizontal lines into a number of small squares drawn to scale, every one of these squares may be made to represent a group of facts or events in relation to time or other condition, and a line drawn through the intersection of these relational lines will often represent with greater clearness the exact relations which these facts or events bear to such conditions than if they were represented in tabular form.

When facts are represented by figures or numerical values, what is called the *arithmetical mean* or simple average is obtained by dividing the sum of these values by the number of facts, and the more numerous the facts, the more trustworthy become the average and proportional results.

This was well shown by the late Dr. Guy, in his extended inquiry into the average age at death of members of the aristocracy who had attained the age of twenty-one years and upwards. The number of cases inquired into amounted

to several hundreds, and Dr. Guy arranged his facts first into groups of 25 each; then two successive groups of 25 were formed into 50, the groups of 50 into 100, and so on until the last totals were obtained:—

Number of Facts.	Average Age at Death. Max.	Min.	Range.
25	69·40	50·64	18·76
50	66·44	55·20	11·24
100	63·70	56·85	6·85
200	62·38	57·61	4·77
400	61·10	58·24	2·86
800	60·84	59·67	1·27
1000		60·25	

If 60 be assumed to be the true average of life among the members of the aristocracy who have attained their twenty-first year, and decimals be discarded, the second table will represent the extreme error which would have been committed by relying on 25, 50, 100, etc., facts respectively:—

Number of Facts.	Error in Excess or Defect.
25	9½
50	6½
100	3½
200	2½
400	1½
800	0½

This is an instance of eliminating error by the test of *successive means*, and it clearly illustrates how, as the number of facts accumulate, the successive averages approach to the mean average of the whole. It is, however, always possible that the average of a small number of facts may give a close approximation to the average of a long series, but such an average requires further confirmation. Whether the series be long or short, it should always be remembered that the results can never be applied to a single case. It is also an axiom in statistics that the less the difference between the average and the figures of a series, the greater is its value.

Another criterion in the estimation of the value of a series is the divergence of the individual terms of the series from its mean. What is called the *mean error* is obtained as follows:—First find the mean of the series, then find the mean of all the observations or facts above the mean, and subtract the mean from it. This gives the mean error in excess. Secondly, find the mean of all the series below the mean. This gives the mean error in deficiency. Add together the mean error in excess and the mean error in deficiency, and the mean or average of these is what is called the *mean error*. The greater the mean error the greater is the need for an extended series of facts or observations on which to base reliable conclusions.

What is called the *probable error* is obtained by multiplying the mean error by ·6745, or $\frac{2}{3}$ nearly, and is useful in showing that the smaller the latitude of error, the more trustworthy is the series from which the mean or average is drawn. It is also useful in comparing the value of two or more similar groups, the relative values being inversely as the squares of the probable errors of each. Thus, if in two similar groups A and B, A has a probable error of 8 per cent, and B of 4 per cent, the squares of the probable errors will be respectively 64 and 16, or the group B will have a value four times greater than group A. Finally, it has to be noted that the value of a series of observations increases as the *square root* of the number. Thus, a group of 9 observations is to a group of 100 as $\sqrt{9}$ to $\sqrt{100}$, or as 3 to 10.

The degree or extent to which proportional results from large or small numbers of observations deviate from the truth may also be determined by *Poisson's Formula.*

Thus, let M = total number of cases or units in the series, m = number of cases in one group, and n = number of cases in the other group. Then $m + n = \mathrm{M}$, and $\frac{m}{\mathrm{M}}$ and $\frac{n}{\mathrm{M}}$ are the proportions of each of these two series to the whole.

But these proportions will vary within certain limits on subsequent occasions, with another series of similar cases, and the extent of the variation will be limited by

$\frac{m}{M}+2\sqrt{\frac{2mn}{M^3}}$ and $\frac{m}{M}-2\sqrt{\frac{2mn}{M^3}}$ as regards the m group, and the same will hold good with regard to the n group. It is evident that the larger the number of M, the less will be the value of $2\sqrt{\frac{2mn}{M^3}}$, and the less the limits of error in $\frac{m}{M}$ or $\frac{n}{M}$. Thus, let it be assumed that out of 100 cases of fever, 30 die and 70 recover; how far will this ratio apply to other series of cases of the same fever? By Poisson's formula the error in this instance will be ·129 to unity, so that the range of possible recoveries out of 100,000 cases on this limited basis would be

$$70{,}000 + 12{,}900 = 82{,}900,$$

and

$$70{,}000 - 12{,}900 = 57{,}100.$$

If, however, 1000 cases are taken, out of which 700 recover, the error will be only ·04 to unity, and the range of recoveries, out of 100,000 cases, will lie between

$$70{,}000 + 4000 = 74{,}000,$$

and

$$70{,}000 - 4000 = 66{,}000.$$

With 10,000 cases observed the range of recoveries would lie between 71,290 and 68,710, while with 100,000 cases it would lie between 70,400 and 69,600, which approaches more closely to certainty. It is thus seen that by increasing the number of observations from 100 to 10,000 the accuracy is increased tenfold, because in the former instance the range of possible recoveries out of 10,000 cases is 25,800, and in the latter only 2580. In other words, the degree of accuracy increases as the square root of the number of observations. (See De Chaumont's *State Medicine.*)

Fellers Slide Rule Calculating Machine

CHAPTER XIX

SANITARY LAW

In the introductory chapter, brief reference was made to the numerous more important legislative enactments which have been passed during the last half century for the protection of the public health and prevention of disease, but it may be said generally that sanitary law as at present enforced in the several parts of the United Kingdom is mainly based on four principal Acts, namely, the Public Health Act, 1875, which applies to England and Wales; the Public Health (London) Act, 1891, which applies to the Metropolis; the Public Health (Scotland) Act, 1897; and the Public Health (Ireland) Act, 1878. The Public Health (London) Act, being of comparatively recent date, forms a more or less complete sanitary code for London, but in respect to extra-metropolitan England, there are as many as fourteen separate Acts which amend or supplement the Public Health Act, 1875. There is thus pressing need for an Act similar to the London Act, or the Public Health (Scotland) Act, 1897, to consolidate and amend the laws relating to public health in England and Wales, as well as another such Act to meet the public health requirements of Ireland. Instead, therefore, of dealing separately with the Public Health Act, 1875, and all these other supplemental Acts passed since that year, which apply to England and Wales, it will be convenient to summarise, under various headings, the more important provisions contained in them, which concern the duties of sanitary officials, and in passing, refer to the

provisions of the Acts which similarly apply to London, Scotland, and Ireland, respectively.

But in addition to these numerous Acts, there are several other Acts which apply to the whole of the United Kingdom, such as the Housing of the Working Classes Acts, the Factory and Workshops Acts, the Alkali Acts, the Food and Drugs Adulteration Acts, the Rivers Pollution Acts, and the Dairies, Cow-sheds, and Milk-shops Orders under the Contagious Diseases (Animals) Acts; while there are others which are still adoptive in certain parts of the kingdom, such as the Infectious Diseases (Notification) Act, 1889, the Public Health Acts (Amendment) Act, 1890, and the Infectious Diseases (Prevention) Act, 1890. The important provisions of these three Acts have been practically incorporated in the Public Health (London) Act, 1891, and the Public Health (Scotland) Act, 1897, but they still continue to be adoptive Acts so far as England and Wales, and Ireland, are concerned.

All these Acts, however, and others which will also receive notice, will be dissected and grouped under the various headings to which they apply; and the more important bye-laws and regulations authorised by them will likewise be summarised.

I.—Administrative Areas and Local Sanitary Authorities

For sanitary and other local government purposes, the whole of England and Wales, outside London, is divided into administrative counties and county boroughs. An administrative county may either be a whole county, or part of a county, such as the Ridings of Yorkshire. By the Local Government Act, 1888, every borough, which contained a population of 50,000, or was a county borough of itself, was created an administrative county; and the corporation, or municipal council, constitute the urban sanitary authority. Under the provisions of the Local Government Board Act, 1894, known as the Parish Councils

Act, the administrative counties, exclusive of the county boroughs which are deemed to be urban districts, are divided into county districts, some of which are urban and others rural. The urban districts include the smaller boroughs and other towns formerly governed by local boards, and the corporation, or district council, of each of these, as the case may be, constitute the urban sanitary authority; while, in rural districts, the district council constitute the rural sanitary authority.

The Local Government Board Act, 1894, also created parish councils in every rural parish with a population of 300 and over, and county councils were empowered to establish parish councils by order, provided they received a resolution to that effect, in parishes with a population of less than 100; or they may establish a parish council for two or more neighbouring parishes with the consent of such parishes.

Leaving the limited sanitary powers of county councils and parish councils to be summarised later on, it may be said generally that the powers, duties, and liabilities conferred by the Public Health Act, 1875, and the other Acts referred to, are exercised throughout England and Wales by the corporations of boroughs, and the councils of other urban districts as urban sanitary authorities, and by rural district councils as rural sanitary authorities, with all the powers and obligations which were exercised by the old boards of guardians as such. Parts of unions, however, which extended into other counties were, by the 1894 Act, created separate rural districts, and the Local Government Board were empowered to increase the number of councillors, if less than five to that number, or to order the affairs of any such district to be administered by the district council of an adjoining district in another county, with which it may or may not have been united before the passing of the Act.

Both urban and rural district councils may appoint committees for the exercise of sanitary powers, consisting either wholly or partly of their members; but no such committee can hold office beyond the next annual meeting of the council appointing them, and all their acts must be

intimated to the council for approval. A rural district council is further empowered by Section 15 of the 1894 Act to delegate to a parish council any powers which it may delegate to a parochial committee under Section 202 of the Public Health Act, 1875, namely, to inspect and report on the condition of their district, recommend works and supervise the execution of them; to inquire into and report on nuisances; to examine and certify all accounts relative to expenditure within their district; and generally to report to the rural sanitary authority on all matters requiring attention, and as to the way in which the officials of the authority have discharged their duties. A parochial committee, however, is merely the agent of the district council, and the appointment of the committee does not relieve the rural authority of any obligation imposed on them by Act of Parliament or otherwise.

As will be shown later on, under the heading of "Bye-laws and Regulations," the powers conferred on urban authorities are far more comprehensive than those exercised by rural authorities, but by Section 276 of the Public Health Act, 1875, the Local Government Board may, on the application of any rural authority, or of persons whose poor-rate assessments amount to one-tenth of the net rateable value of the district, declare, by order, any provision of that Act, in force in any urban sanitary district, to be in force in such rural sanitary district, or part thereof. Such an order is said to confer urban powers on a rural sanitary district, and similar powers may be obtained by the adoption of Part III. of the Public Health Acts (Amendment) Act, 1890. Urban powers may also be obtained to carry out the provisions of the Private Streets Act, 1892, and under the Local Government Act, 1894, the Local Government Board may further confer such urban powers as they may see fit.

Throughout England and Wales there is practically only one sanitary authority acting for each district, whether urban or rural, but in **London**, with the exception of the Port of London, which is under the city corporation, there is no part where the functions of a sanitary authority are

not exercised by more than one public body. By Section 99 of the Public Health (London) Act, 1891, the authority called the sanitary authority is—in the city, the Commissioners of Sewers; in certain parishes, the vestry; in Woolwich, the Local Board of Health; in certain other districts, the district boards, and in some other places, the guardians or overseers.

In **Scotland,** Section 12 of the Public Health (Scotland) Act, of 1897, determines the local authorities to execute this Act as follows:—In burghs, the town council, burgh commissioners, or board of police, as the case may be; in districts, where the county is divided into districts under the Local Government (Scotland) Act, 1889, the district committee; and in counties, where the county is not so divided, the County Council. The central authority is the Local Government Board of Scotland.

There are no powers for conferring urban or burghal powers on district committees or landward local authorities except by the constitution of a new police burgh. By Section 44 of the Local Government (Scotland) Act, 1894, district committees can constitute special districts in what are called landward areas, for lighting, scavenging, and provision of baths, wash-houses, and drying grounds. The parish councils, constituted in place of the old parochial boards, have no important duties of sanitary administration. Section 14 of the Public Health (Scotland) Act, 1897, empowers any district committee to appoint a committee or committees of their own body to authorise a duly appointed officer to issue notices, make complaints, and take proceedings, and all such acts and proceedings become as valid as if executed in the name of the local authority.

In **Ireland,** the central authority is the Local Government of Ireland. By the Public Health (Ireland) Act, 1878, the whole of Ireland is divided into urban and rural districts, and the administrative authorities are the urban and rural sanitary authorities. But no doubt there will be considerable alterations in respect to both areas and authorities in the forthcoming Local Government Act for Ireland.

II.—Alteration of Areas, Contributory Places, and Union of Districts

Section 270 of the Public Health Act, 1875, empowers the Local Government Board by provisional order to dissolve any local government district, and to merge any such district in some other district or districts, and to make other alterations with respect to districts, whether *urban* or *rural;* while Section 271 empowers the Board to declare any *rural* district, or any portion of a *rural* district, to be a local government or *urban* district.

(Similar powers, subject to the approval of the Local Government Board, are conferred on county councils by Section 57 of the Local Government Board Act, 1888, on a *prima facie* case being made out, with respect to any district not a borough, or with respect to any parish, as regards—"(*a*) alteration or definition of the boundary thereof; (*b*) the division thereof or the union thereof with any other such district or districts, parish or parishes; (*c*) the conversion of any such district or part thereof, if it is a *rural* district, into an *urban* district, and if it is an *urban* district into a *rural* district, or the transfer of the whole or any part of such district to another, and the formation of new *urban* or *rural* districts; and (*d*) the division of an *urban* district into wards.")

Section 277 of the Public Health Act, 1875, renders it lawful for a *rural* authority, by a resolution to be approved of by the Local Government Board, to constitute any portion of their district a special drainage district, for the purpose of charging thereon exclusively the expenses of sewerage, water-supply, or of other works which may be declared special expenses, and thereupon such area will become a separate "contributory place." On the application of local authorities to the Local Government Board, Sections 279 and 280 empower the Board, by provisional order, to form a united district—either for procuring a common water-supply; for carrying out a joint-system of sewerage, or common outfall sewer; or for other purposes of the Act, such as erecting a hospital for the use of the several districts concerned; and the governing body of a united district shall be a joint-board, consisting of such members as the Local Government Board may determine by their provisional order. Section 283 enacts that any expenses incurred by a joint-board in pursuance of the Act shall be defrayed out of a common fund to be contributed by the contributory places *pro rata*, or otherwise, as the order may determine; and Section 284 provides that the joint-board shall issue their precept to each contributory local authority to pay their quota to such expenses. Section 285 gives power to local authorities to execute works in adjoining districts with the consent of the local authorities of those districts, and to combine with neighbouring authorities for the execution of such works.

As will be shown subsequently, county councils are empowered by the Isolation Hospital Act, 1893, to issue orders constituting hospital districts under certain restrictions, and also hospital committees.

In **Scotland,** powers and obligations are conferred on local authorities, not being burghs, by Section 122 of the Public Health (Scotland) Act, 1897, to form, combine, alter, or dissolve, special drainage districts, subject to the approval of the sheriff of the county, and similar powers are conferred in respect to water-supply, under Section 131 of the same Act.

In **Ireland,** the Local Government Board is empowered by Section 12 of the Public Health (Ireland) Act, 1878, to form united districts for water-supply, sewerage, or other purposes of the Act, by provisional order, and appoint joint boards as governing bodies.

III.—Definitions

There are certain words or expressions used in the Public Health and other Sanitary Acts to which more or less strict legal definitions are assigned, and in dealing with these, as well as the excerpts which will appear under the various headings, it will be understood that they all apply to England and Wales except when otherwise stated.

The more important of the definitions are the following:—

"Lands" and "premises" include messuages, buildings, lands, easements, and hereditaments of any tenure. (According to the Public Health (Scotland) Act, 1897, "premises" also include buildings, vehicles, tents, vans, structures of any kind, etc., within the limits of the local authority.)

"Building," though not strictly defined, includes wooden structures on wheels, and also those without foundations but simply resting on the ground. Under the Infectious Diseases Notification Act, 1889, it applies to boats, vessels, ships, tents, vans, sheds, and other structures used for human habitation.

"House" means a dwelling-house, and includes schools, and also factories, in which persons are employed.

"Owner" means the person who, for the time being, receives the rack-rent of the lands or premises in connection with which the word

is used, whether on his own account, or as agent or trustee for any other person, or who would so receive the same if the premises were let at a rack-rent, that is a rent less than two-thirds of the full net annual value of the property. (In the Public Health (Scotland) Act, 1897, the definition is much simpler, and means the person entitled to receive, or who would, if the same were let, be entitled to receive the rents of the premises.)

"Curtilage" is defined as a courtyard, back, side, or piece of ground, lying near to a dwelling-house.

"Slaughter-house" includes the buildings and places commonly called slaughter-houses and knackers' yards, and any building or place used for slaughtering cattle, horses, or animals of any description for sale.

"Water-works" include streams, springs, wells, pumps, reservoirs, cisterns, tanks, aqueduct, cuts, sluices, mains, pipes, culverts, engines, and all machinery, lands, buildings and things for supplying or used for supplying water, also the stock-in-trade of any water company.

"Sanitary convenience" includes urinals, water-closets, earth-closets, privies, ash-pits, and any similar convenience.

"Ash-pit" includes any ash-tub or other receptacle for the deposit of ashes, fæcal matter, or refuse.

"Earth-closet" is defined as any place for the reception and deodorisation of fæcal matter, constructed to the satisfaction of the local authority.

"Street" includes any highway, not being a turnpike road, and any public bridge (not being a county bridge), and any road, lane, footway, square, court, alley, or passage, whether a thoroughfare or not; but under the Housing of the Working Classes Act, 1890 (Section 29), the word "street" is restricted to a road, etc., in which houses are built.

"Drain" means any drain of, and used for the drainage of, one building only, or premises within the same curtilage, and made merely for the purpose of communicating therefrom with a cess-pool or other like receptacle for drainage, or with a sewer into which the drainage of two or more buildings or premises occupied by different persons is conveyed.

"Sewer" includes sewers or drains of every description, except drains to which the word "drain" as interpreted aforesaid applies, and except drains vested in or under the control of any authority having the management of roads and not being a local authority under the Public Health Act, 1875.

According to this definition, a sewer is a drain receiving the drainage of two or more buildings or premises within the same curtilage, and, as decided in courts of law (see Lumley's *Public Health*), may be an open channel or ditch, such as a polluted watercourse. It is clear, too, that in

respect to numerous villages scattered all over the country through which county roads pass, there may arise conflict between county councils and rural district councils, because where no separate scheme of sewerage has been carried out, the road-drains receive the drainage of the houses as well as the surface-water, and are virtually sewers. But county councils can claim them as road-drains, and though they might therefore be held legally responsible for any nuisance or pollution at the outfall, or for any nuisance arising from improperly trapped gratings, it is always advisable by mutual agreement that district councils as the rural sanitary authorities should take them over as sewers, keep them in repair, and abate any nuisance connected with them whether in respect to the outfall or elsewhere. This also applies to the village drains of district roads, but in either case equitable arrangements should always be made if any repairs or alterations are deemed necessary for taking off the surface-water, because sewer expenses fall on a parish or contributory place, and road expenses on a district or county.

In the Public Health (Ireland) Act, 1878, the definitions of "sewer" and "drain" are the same as the above, but in the Public Health (Scotland) Act, 1897, no definition is given beyond that contained in Section 101, which vests all sewers existing within a district, and not being private or Crown property, in the local authority. Under the Metropolis Local Management Act of 1862, the above distinction between drain and sewer does not hold good, and a combined drain is deemed to remain a drain and not a sewer. There is also confusion between the above definitions of the Public Health Act, 1875, and those represented under Section 19 of the Public Health Acts (Amendment) Act, 1890, for the reason that in any district which adopts Part III. of that Act, whether urban or rural, a combined drain, or pipe which receives the drainage of two or more buildings, is deemed to be a sewer, only if all the houses draining into it belong to one owner. If they belong to more than one owner the combined drain is repairable at

the expense of the owners, and not a sewer repairable at the expense of the sanitary authority.

IV.—Sewerage and Sewage Disposal

By Section 13 of the Public Health Act, 1875, all sewers, except certain private sewers, are vested in the local authority of the district. Section 14 empowers local authorities to purchase or construct sewers, while Section 15 renders it incumbent on them to keep all sewers belonging to them in proper repair, and to construct such sewers as may be necessary for effectually draining their districts. (Neglect of these duties is made a default by Section 299 of the Act, and further powers are given in this respect by Sections 17 and 19 of the Local Government Act, 1894, to county councils on complaint by a parish council.) Section 19 of the 1875 Act enjoins that all sewers must be constructed, ventilated, and kept so as not to be a nuisance or injurious to health, while Section 27 prohibits the erection of unauthorised buildings over them.

Under Sections 28, 29, 30, sanitary authorities are empowered to deal with land appropriated for sewage purposes, to contribute by mutual agreement to works executed by other authorities for the disposal of their sewage, and to agree for communication of their sewers with the sewers of adjoining districts.

(By Section 7 of the Rivers Pollution Act, 1876, every sanitary authority is bound to give facilities for manufactories to drain into sewers, but by Sections 16 and 17 of the Public Health Acts (Amendment) Act, 1890, provision is given for the protection of sewers from injurious matters, such as anything which may impede the flow of their contents, or any chemical refuse, waste, steam, or water or liquid of a temperature above 110° F.)

In **London,** the County Council constitute the local authority for the main sewerage of the metropolis and the disposal of the sewage; while the vestries and district boards are the local authorities for the purposes of sewerage and drainage other than the main sewerage, but the County Council have power to declare sewers to be main sewers, and have control over the local authorities in regard to the construction of sewers by means of bye-laws. All sewers within the city are vested in the commissioners.

In **Scotland** and **Ireland,** the provisions under the respective Public Health Acts relating to sewerage and sewage disposal do not differ materially from those applying to English sanitary districts.

V.—House Drainage and Refuse Removal

1. *House drainage.*—Sections 21-25 of the 1875 Act empower local authorities to enforce the drainage of any house which is without a sufficient drain or drains, and to prescribe the materials, size, level, and fall. If the site of the house is within 100 feet of any sewer belonging to the authority, the drain must be made to discharge into such sewer; but if the site is beyond this statutory distance, then it must discharge into a covered cess-pool, but not under a house, and in such position as the authority may direct. Failing compliance with due notice the authority may carry out the work, and recover the expenses incurred. Owners and occupiers within a district are empowered to drain into the sewers of the local authority. In an *urban* district, or any district vested with *urban* powers, no new house, nor any house which has been rebuilt, can be occupied, unless it is drained to the satisfaction of the authority. (In places where Part III. of the Public Health Acts (Amendment) Act, 1890, has been adopted, the owner or occupier has a right to require the sanitary authority to connect his drains with a public sewer at his cost [Section 18].)

2. *Water-closets, privies, etc.*—Section 35 renders it unlawful to erect or rebuild any house without a sufficient water-closet, earth-closet, or privy, and an ash-pit (ash-pit midden), furnished with proper doors and coverings; while Section 36 empowers a local authority, on the report of their surveyor or inspector of nuisances, to enforce the provision of the same for any existing house, and the authority may require a separate closet for each house, if in their opinion it is deemed necessary. Failing compliance with due notice, the authority may carry out the work required to be done, and recover from the owner the expenses incurred. Under Section 37, earth-closets may be constructed instead of water-closets with the approval of the local authority, and the authority may undertake or contract to supply dry earth or other deodorising substance for such closets. Section 38 empowers local authorities to enforce adequate and separate closet accommodation for the use of both sexes employed in factories.

3. *Public Conveniences.*—Under Section 39 *urban* authorities are empowered to provide public closets, urinals, and other similar conveniences for the accommodation of the public.

(In districts where Part III. of the Public Health Acts (Amendment) Act 1890, has been adopted, Section 20 of that Act provides that where an *urban* authority provide and maintain for public accommodation any sanitary conveniences, they may (1) make regulations for the management thereof, and bye-laws for decent use; (2)

may let the same for any term not exceeding three years; and (3) may charge fees for the use of any water-closets. No public sanitary convenience can be erected in or accessible to any street without the consent of the sanitary authority, and on such terms as regards use and removal as they may think fit. Any contravention of this enactment renders an offender liable to a penalty. This section, however, does not apply to railway companies in respect to sanitary conveniences within their own property.

As regards sanitary conveniences used in common by the occupiers of two or more dwelling-houses, Section 21 of the same Act provides that (1) any person fouling or injuring such convenience is liable to a penalty, and (2) that if nuisance arises from want of cleanliness of any part of a convenience, or of the approaches thereto, each of the persons having the right of use is liable to a penalty, if it cannot be proved which of them is in default. Section 22 enacts that sufficient and suitable sanitary conveniences must be provided for all workshops and manufactories, with separate accommodation for each sex, where persons of both sexes are employed. If the surveyor reports that the provisions of this section are not complied with, the authority may give notice, and failing compliance, a penalty not exceeding £20 is incurred. Where the above section is in force, Section 38 of the 1875 Act is repealed.)

Section 40 of the 1875 Act enjoins that every local authority "shall provide that all drains, water-closets, earth-closets, privies, ash-pits, and cess-pools, within their district, be constructed and kept so as not to be a nuisance or injurious to health." If a local authority neglects this important duty, they may be declared a defaulting authority under Section 299.

Section 41 enacts that if on written complaint, any drain, closet, ash-pit, or cess-pool, is declared to be a nuisance, or injurious to health, the local authority may empower their surveyor or inspector to enter the premises after giving twenty-four hours' notice, except in cases of emergency, and open the ground, in order to make due examination. If no defects are found, the authority must close the ground and make good any damage; but if any defects are discovered the authority must forthwith serve notice on the owner or occupier, and failing compliance, they may themselves execute such works as they may deem necessary, and recover the expenses incurred from the owner.

Section 157 empowers urban authorities, and rural authorities vested with urban powers, to make bye-laws with respect to the drainage of new buildings. (In all places, whether urban or rural, where the Public Health Acts (Amendment) Act, 1890, has been adopted, Section 23 of this Act gives power to make bye-laws applying to old buildings as well as new.)

The Model Bye-Laws issued by the Local Government Board with respect to the drainage of buildings will be

more fitly summarised under the heading "New Streets and Buildings" (see *post*, p. 678).

In **London,** Section 39 of the Public Health (London) Act, 1891, empowers the London County Council to make similar bye-laws with respect to the house drainage, accessories, etc., of new and old buildings, which the sanitary authorities are bound to observe and enforce, but such bye-laws do not extend to the city. The powers and obligations of a sanitary authority in respect to house drainage and refuse, are similar to those of a sanitary authority in other parts of the country, but, as will be subsequently shown, are of a more definite and restrictive character.

In **Scotland,** Sections 238-245 of the Burgh Police Act, 1892, give powers to burghal authorities similar to the English provisions, while under Section 181 of the Public Health (Scotland) Act, 1897, the local authority of any district, other than a burgh, may make bye-laws subject to the approval of the County Council for the whole or any part of their district, for regulating the building or rebuilding of houses or altering the same, and for the construction and arrangement of drains, closets, ash-pits, etc.

In **Ireland,** power is given to rural as well as urban sanitary authorities, by Section 41 of the Public Health (Ireland) Act, to make bye-laws similar to those in force in England with respect to the regulation of buildings, house drainage, etc., but no model bye-laws have been issued by the Irish Board, as those issued by the Local Government Board of England generally apply.

VI.—Scavenging and Cleansing

Under Section 42 of the Public Health Act, 1875, every local authority may, and when required by the Local Government Board, *shall* themselves undertake or contract for the removal of house refuse from premises, and the cleansing of earth-closets, privies, ash-pits, and cess-pools, either for the whole or any part of their district. Further, every urban authority, or rural authority invested with urban powers, may, and when required by the Local Government Board *shall*, themselves undertake the cleansing of streets, and may

also undertake the watering of the same. Where the scavenging is undertaken by the authority, any occupier of premises may claim a penalty from the authority if they neglect, after written notice, to attend to the proper scavenging of his premises within seven days (Section 43).

Section 44 provides that where any local authority, whether urban or rural, do not themselves undertake or contract for the scavenging of their district, they may make bye-laws imposing upon the occupiers of premises the duty of cleansing the footways or pavements adjoining any premises, the removal of house refuse, the cleansing of earth-closets, privies, ash-pits, and cess-pools belonging to such premises, at such intervals as they think fit; and further, that every *urban* authority may make bye-laws for the prevention of nuisances arising from snow, filth, dust, ashes, and rubbish, and for the prevention of keeping of animals on any premises so as to be a nuisance or injurious to health.

The following is a summary of the Model Bye-Laws issued by the Local Government Board in accordance with the terms of this section:—

1. *Private Scavenging* (rural and urban authorities).—The occupier of any premises must cleanse the footways and pavements adjoining his premises *daily* except Sunday. He must remove the house refuse *once a week*, and excreta at intervals not exceeding the following maximum limits:—

Earth-closets with fixed receptacle . . .	*Every three months.*
Earth-closets with movable receptacle . . .	*Once a week.*
Privies, whether the receptacle is fixed or movable .	,,
Ash-pits, whether receiving excreta or not . .	,,
Cess-pools	*Every three months.*

2. *Prevention of Nuisances* (urban authorities):—

(1) *Clearing away Snow* from the footways and pavements adjoining premises as soon as possible after it falls.

(2) *For Scavenging.*—The filth, dust, or ashes from any premises shall not be deposited on any footway, pavement, or carriage way, and must if necessary be removed in a suitable covered receptacle or cart to prevent spilling. Any such refuse accidentally falling upon a footway or road must be immediately removed, and the place cleaned. If the premises are within 20 yards of any dwelling, school, public building, or place of business, the occupier shall not scavenge any privy or other such receptacle for filth except between the hours of *7 A.M. and 9.30 A.M.* during the months of November, December, January, and February, and between *6 A.M. and 8.30 A.M.* during the other months of the year.

(3) *Removal and Deposit of Night-soil or other Filth.*—Any one removing night-soil or other filth through the streets must do so in carts, or rather receptacles which must be covered, if deemed necessary, to prevent spilling, and any matter so spilled on the streets and roads must be removed and the place cleaned. No load of filth must be deposited within *100 yards* of any street, dwelling-house, school, public building, or place of business, nor must it be permitted to remain there for more than (say) 24 hours. Night-soil intended for agricultural purposes must not be deposited on land within *100 yards* of any street, or dwelling, etc., and, if not deodorised, must be at once dug or ploughed into the ground. (Further powers for framing bye-laws both in

respect to scavenging and carriage of night-soil are conferred by the Public Health (Amendment) Act (see *ante*, p. 615).

(4) *Keeping of Animals.*—Swine shall not be kept within *60 or 100 feet* of any dwelling-house, nor in such a situation as to pollute water likely to be used for domestic or dairy purposes, or the manufacturing of drinks. The same prohibition as regards water-pollution apply to the keeping of cattle and the storage of dung.

(5) *Construction of Premises.*—Every occupier of premises in which swine, cattle, horses, etc., are kept must provide a suitable receptacle for dung, manure, etc. Such receptacle must be entirely above the level of the ground, be made water-tight and covered, and it must be cleansed at least *once a week*. The drain must be properly constructed and kept in order at all times, so as to convey all liquid filth to a sewer, cess-pool, or other suitable receptacle.

By Section 45 of the Act an urban sanitary authority may provide receptacles and places for the temporary deposit of the matter collected.

Section 46 empowers local authorities to order the cleansing and whitewashing of filthy houses, and the cleansing and purifying of infected houses, on the certificate of the medical officer of health or of any two medical practitioners. Section 47 applies only to *urban* authorities, and renders it unlawful to keep swine in any dwelling, so as to be a nuisance to any person, or to suffer any waste or stagnant water to remain within any dwelling-house for twenty-four hours after written notice from the authority, or to allow the contents of any water-closet, privy, or cess-pool to overflow or soak therefrom. In case of non-compliance with notice the occupier renders himself liable to a penalty, and the *urban* authority may themselves abate the nuisance and recover the expenses incurred from the occupier.

Section 48 empowers local authorities to obtain an order from the justices for the cleansing of offensive ditches or watercourses lying near to or forming the boundaries of their districts. The next two sections apply only to *urban* districts. Section 49 authorises the inspector of nuisances to give notice to the owner or occupier of premises to remove collections of manure or other offensive matter, and if not removed within twenty-four hours any such filth accumulations become the property of the authority, to be disposed of by them; while Section 50 empowers the urban authority to give public notice requiring the periodical removal of manure or other refuse matter from mews and other premises, and failing compliance penalties are incurred.

(In places where Part III. of the Public Health (Amendment) Act, 1890, has been adopted, the sanitary authority is empowered to keep common courts and passages clean, and to apportion the expenses incurred on the occupiers of the adjacent buildings.)

In **London**, the sanitary authorities are *compelled* by Sections 29 and 30 of the Public Health (London) Act, 1891, to cleanse streets, footpaths, cess-pits, and privies, and remove house refuse at proper intervals, and trade refuse, when required to do so, on payment. They may also undertake

the collection and removal of manure and other refuse on request, or may by order require periodical removal by owner (Section 36). Section 16 empowers the County Council to make bye-laws in respect to the times for removal of house refuse through London, and the prevention of nuisance. Section 17 prohibits the keeping of swine within 40 yards of a street or public place, while Section 18 gives power to prohibit the keeping of animals in any place unfit for the purpose.

In **Scotland,** burgh scavenging and cleansing is fully regulated by Sections 107, 127, 316 of the Burgh Police (Scotland) Act, 1892, which vest in the burgh commissioners, or town councils, powers similar to those in force in England and Wales. With regard to landward districts, Section 39 of the Public Health (Scotland) Act, 1897, provides that where a scavenging district has been, or may be, formed, the district committee of the district or the County Council, where the county is not divided into districts, have power to scavenge highways and footpaths, and pay out of the assessments rates for roads and bridges, but they have no power to make bye-laws. County councils may, however, impose certain obligations by means of bye-laws for the abatement of nuisance (see *post*, p. 637).

In **Ireland,** Section 52 of the Public Health (Ireland) Act, 1878, confers the same powers and obligations as Section 42 of the English Act, 1875, but they only apply to urban authorities. Under Section 54, power is given to the Local Government Board for Ireland to require urban authorities to make bye-laws imposing the duty of cleansing, etc., on occupier, while Section 55 empowers all sanitary authorities to provide receptacles for the temporary deposit of rubbish. Section 57 imposes penalties for the keeping of swine in houses, or so as to be a nuisance, and for allowing soakage or overflow from cess-pools or privies, in rural as well as in urban districts. Powers similar to those in England are conferred on sanitary authorities for the cleansing or purifying of houses on certificate by Section 56.

VII.—River Pollution

Before proceeding to deal with the enactments relating to water-supply, it will be convenient to summarise the provisions of the Rivers Pollution Acts 1876 and 1893, which have already been referred to under the heading of "Sewerage and Sewage Disposal."

The 1876 Act deals with four different kinds of pollution, viz. (1) solid matters, (2) sewage, (3) trade effluents, (4) mining effluents.

(1) No solid refuse or waste matter of any kind must be put into any stream so as to obstruct its flow or pollute its waters (Section 2).

(2) No solid or liquid sewage matter must be discharged into any stream; but as regards conditions existing prior to the passing of the Act, no offence is committed under the Act if it can be proved that the best practical and available means have been adopted to purify the sewage before it enters the stream (Section 3). (This section is amended by the short explanatory Act of 1893, which provides that "where any sewage matter flows or is carried into any stream after passing through or along a channel which is vested in a sanitary authority, such authority shall be deemed to knowingly permit the sewage matter so to fall, flow, or be carried.)

(3) No poisonous, noxious, or polluting liquid proceeding from any factory or manufacturing process must be passed into any stream, but the same saving clause as above is repeated in respect to conditions existing prior to 1876 (Section 4).

(4) No solid matter from mines must be put into any stream to obstruct its flow; nor any poisonous, noxious, or polluting solid or liquid matter be passed into any stream, other than water which has been raised or drained from such mine (Section 5).

According to Section 6, proceedings cannot be taken against any person under Sections 4 and 5 save by a sanitary authority, nor can the authority proceed without the consent of the Local Government Board. On complaint of any person, however, the Board may direct the sanitary authority to proceed if satisfied that there is sufficient cause, but in giving or withholding their consent, the Board shall have regard to the industrial interests involved, and the circumstances and requirements of the locality; nor shall the Board give their consent to proceedings in respect to any manufacturing industry, unless they are satisfied, after due inquiry, that means for rendering harmless the effluents from the processes of such manufactures are reasonably practicable and available, and that no material injury will be inflicted on the industry by such proceedings.

Section 7 enacts that every sanitary authority must give facilities for admitting trade effluents into their sewers, unless such effluents would injure the sewers, or interfere with the disposal of the sewage, or would, from their temperature or otherwise, prove injurious from a sanitary point of view; or unless the sewers are only sufficient for the requirements of their district, or where such facilities would interfere with any order of a competent court of jurisdiction respecting the sewage of such authority.

Section 8 gives power to every sanitary authority to enforce the provisions of the Act in respect to any stream passing through their district, and, as will be subsequently shown, county councils or joint-committees appointed by such councils have similar powers conferred on them by the Local Government Act of 1888.

According to Section 10, proceedings are to be taken before the County Court having jurisdiction in the place where offence against the Act has been committed, and the court may issue such order as the circumstances and nature of the pollution warrant, and may impose a daily penalty not exceeding £50 for a continuing offence, or it may suspend or rescind the order; but power of appeal is granted by Section 11 to the higher courts.

Although considerable progress has been made during recent years in abating river pollution, whether arising from sewage or trade refuse, it must be confessed that rivers which received sewage effluents can never be regarded as absolutely safe sources of water-supply, because during times of heavy rainfall it is impossible to prevent serious pollution, no matter what means or methods of sewage purification have been adopted.

VIII.—Water-Supply

Section 299 of the Public Health Act, 1875, renders it obligatory on every sanitary authority to provide their districts with a proper water-supply in cases where danger arises to the health of the inhabitants from insufficiency or unwholesomeness of any existing supply, and provided that a proper supply can be obtained at a reasonable cost. If they neglect to discharge this duty, proceedings can be taken by the Local Government Board, on complaint being made, to enforce it (or, in the case of a rural authority, they can be compelled by the County Council, under Sections 16 and 19 of the Local Government Act, 1894, to provide a proper supply for any parish, on complaint being made, and failing compliance, the County Council may take over to themselves the powers of the authority for the purpose, or may

make an order for the necessary works to be carried out by the authority, or by some person appointed by the County Council).

Where a Water Company has Parliamentary powers to supply water over any given area, Section 52 of the 1875 Act provides that every sanitary authority must give notice to the Company, stating the purposes and extent for which it requires water; and if the Company are able and willing to provide a sufficient and proper supply, the sanitary authority may not themselves construct any water-works in that area. Section 322 further provides that, where the supply of water must be taken from a running stream, the sanitary authority must obtain the written consent of any person or persons who have prior claims upon such stream, river, or source.

Apart from these restrictions, Sections 51-70 empower sanitary authorities to construct water-works, or to hire or purchase such works, or to contract for supplying water to any part or parts of their district, or to neighbouring districts if sanctioned by the Local Government Board. They have the same powers of carrying mains within or without their districts as for laying sewers. Section 55 renders it incumbent on them to provide and keep in any water-works constructed or purchased by them a supply of pure and wholesome water. They have power to charge water-rates or rents, or may supply water by meter. When houses are without water they may, on notice, require owners to provide a proper supply if it can be furnished at a cost not exceeding the water-rate authorised by any local Act, or at a cost not exceeding twopence a week, or such other cost as the Local Government Board may determine to be reasonable, and failing compliance with the notice they may themselves do all such works as are necessary, and recover the expenses incurred in a summary manner (Section 62). All existing pumps, wells, cisterns, reservoirs, and works used for the gratuitous supply of water are vested in the local authority, and they may maintain such wells or works, even though the district may be supplied by a public company (Section 64). Under Section 68 heavy penalties are incurred for polluting any stream, reservoir, pond, or place for water with gas-washings; and Section 69 empowers any local authority to take proceedings for the purpose of protecting any watercourse within their jurisdiction from pollutions arising from sewage either within or without their district. Section 71 empowers a local authority to obtain a justice's order for the closing of any well or cistern used, or likely to be used, for drinking purposes, when the water is so polluted as to be injurious to health, and the court of summary jurisdiction may order the water to be analysed at the expense of the authority.

section 70

These powers and obligations are largely supplemented by the provisions of the Public Health (Water) Act, 1878. This Act only applies to England and Wales, and for the

most part to *rural* sanitary authorities, though Section 11 empowers the Local Government Board to invest any *urban* sanitary authority with all or any of the powers of the Act for the whole or any part of their district.

Section 3 of this Act enjoins that it shall be the duty of every *rural* authority to see that every occupied dwelling-house within their district has within a reasonable distance a sufficient supply of wholesome water. If the medical officer of health or sanitary inspector reports that any such dwelling-house has not such a supply within a reasonable distance (200 feet), and the authority are of opinion that such supply can be provided at a reasonable cost, the interest on which, at five per cent, shall not exceed twopence per week, or at such other cost, the interest on which at five per cent shall not exceed threepence per week, as the Local Government Board on application by the authority shall deem to be reasonable, and are further of opinion that the expense of the supply ought to be paid by the owner or defrayed as private improvement expenses, then proceedings may be taken as follows:—(1) The authority may serve notice on the owner of the house requiring him within a time specified in the notice, and not exceeding six months, to provide such supply, and do all such works as may be deemed necessary for that purpose. (2) If the notice is not complied with within the time specified, the authority may issue a second notice informing the owner that if the requirements of the first notice are not complied with within one month, the authority will themselves provide such supply, and that the expense will be payable by him, or as a private improvement expense. (3) If at the expiration of one month after the date of the second service, the requirements of the first notice are not complied with, the authority may themselves provide the supply, and for that purpose shall have full powers of entry on premises under Sections 102 and 103 of the Public Health Act, 1875. (4) Any expenses incurred by the authority in providing such supply may be recovered in a summary manner from the owner of the house, or may, at the option of the authority, be declared by their order to be private improvement expenses. (5) Where the owners of two or more houses have failed to comply with the notices, and the authority might under this Act execute the necessary works for providing a water-supply for each, the authority may, if it appears to them desirable, and no greater expense would be incurred, provide a joint supply for those houses and apportion the expenses.

Section 3 further enacts that nothing in this Section relieves the authority from the duty imposed upon them by the Public Health Act, 1875, of providing their district, or any contributory place or part of their district, with a supply of water, when danger arises to the health of the inhabitants either from unwholesomeness or insufficiency. Section 4 gives an owner the right of appeal on the following

grounds :—(1) That the supply is not required ; (2) that the time specified in the notice is insufficient ; (3) that it is impracticable to provide the supply at a reasonable cost ; (4) that the authority ought themselves to provide a supply for the district or contributory place in which the house is situate, or render the existing supply wholesome ; or (5) that the whole or part of the expenses of providing the supply, or making the existing supply wholesome, ought to be a charge on the district or contributory place. If the owner within twenty-one days of the service of the second notice addresses a memorial to the authority stating his objections, the authority cannot themselves provide the supply until they have been authorised by a court of summary jurisdiction or the Local Government Board. If the objections do not include either the grounds (4) or (5), the authority may apply to the court for an order authorising them to proceed, and thereupon the court shall summon the owner, and if satisfied that the objections are not well-founded, shall make an order authorising the authority to proceed with the works in the event of their not being executed by the owner within a time limited by the order. If the objections stated in the memorial are or include (4) and (5), or either of them, the authority is bound to forward a copy to the Local Government Board, who may either cancel the requirement of the authority or confirm the same, with or without modifications. If the Board confirm, they shall issue an order authorising the authority, subject to such modifications as they may prescribe, to execute the works, if not executed by the owner within the time specified ; and any such order may, if the Board think it equitable, apportion the expense between the owner and the authority, or between the owner and any other person or persons interested. If the Board cancel the requirement on the grounds that the authority ought themselves to provide a supply for the district or contributory place in which the house is situated, or to render the supply wholesome, the memorial shall be deemed to be a complaint of default made to the Board against the authority under Section 299 of the Public Health Act, 1875.

Section 5 provides that where the expenses of providing a joint supply for two or more houses are apportioned by the authority, notice of such apportionment shall be given to each of the owners, and if any owner objects he may within twenty-one days apply to a justice, and thereupon the justice may summon the authority and also the other owners to show cause before a court of summary jurisdiction why the apportionment should not be varied, and the court may either dismiss the application or make such order, varying the apportionment as may appear reasonable.

Section 6 renders it unlawful for the owner of any new dwelling-house, or of any dwelling-house which may be pulled down to or below the ground-floor and rebuilt, to occupy the same, or allow it to be occupied unless he has obtained from the authority a certificate on the report of the medical officer of health or sanitary inspector that

there is provided a sufficient supply of wholesome water within a reasonable distance. If the authority refuses a certificate the owner may apply to a court of summary jurisdiction for an order to occupy, and thereupon the court shall summon the authority, and if satisfied, after hearing the case, that a certificate ought to have been granted, they may make an order authorising occupation. Any owner who contravenes this section is liable to a penalty not exceeding £10.

Section 7 renders it incumbent on every *rural* authority to take steps from time to time, either through their officers or otherwise, to ascertain the condition of the water-supply of their district, and for this purpose have full powers of entry on premises under Sections 102 and 103 of the Public Health Act, 1875. Section 8 provides that if a local authority makes application to the Local Government Board under Section 62 of the Public Health Act (see *ante*, p. 623) to determine what is a reasonable cost, the Board may, by order, fix a scale of charges for the whole or any part of the district. Section 9 enacts that when a *rural* authority has provided a stand-pipe or pipes for the supply of any portion of their district, they may recover water-rates from the owner or occupier of any dwelling-house within 200 feet of any such stand-pipe, provided that no rate shall be recoverable from the owner or occupier of any dwelling within that distance which is provided with a proper supply, and the inmates do not use the public supply. Section 10 provides that where a sanitary authority supply water in an *urban* district or in any "contributory place," and an application is made to them by ten ratepayers in such *urban* district, or five in such "contributory place," to charge water-rates or rents in respect of the water so supplied, it becomes incumbent on the authority to exercise the powers vested in them to charge water-rates.

(Section 8 of the Local Government Act, 1894, empowers a parish council to utilise any well, spring, or stream within their parish, and to provide facilities for obtaining water therefrom, provided they do not interfere with the just rights of any person or corporation; but these rights do not in any way derogate from the obligations of a *rural* sanitary authority in respect of supplying water.)

In **London,** as well as throughout an extensive extra-metropolitan area, the water-supply is in the hands of eight water companies, whose powers and rights are regulated by their local Acts, and by the Metropolitan Water Acts of 1852 and 1871. The controlling authority is the Local Government Board, who can approve or disapprove of new sources, repeal or modify regulations, inquire into complaints, and compel a constant supply on request of the County Council to premises in any district where the

approved regulations are in operation and the prescribed fittings have been adopted. On default of the owner or occupier, the County Council have the power to supply the prescribed fittings.

The powers and obligations of the vestries and other local authorities in respect to water-supply are detailed in the Public Health (London) Act, 1891.

Section 48 of that Act provides that any occupied house, without a proper and sufficient supply of water, shall be a nuisance liable to be dealt with summarily under the Act, and if it is a dwelling-house, shall be deemed unfit for human habitation; and further, that no new house, nor any house which is pulled down to or below the ground-floor and rebuilt, shall be occupied until a certificate is granted by the sanitary authority that it is provided with a proper water-supply. Section 49 provides that where a water company may lawfully cut off the water-supply to any inhabited dwelling-house, the company must give written notice to the sanitary authority within twenty-four hours after exercising the said right. Under Section 50 every sanitary authority is compelled to make bye-laws for securing the cleanliness of tanks, cisterns, and other receptacles for the storage of water used, or likely to be used, for drinking purposes, while Section 51 vests in the sanitary authorities all public cisterns, reservoirs, wells, fountains and works used for the gratuitous supply of water in their districts. In order to secure the closure of polluted wells, cisterns, etc., either temporarily or permanently, the sanitary authority has only to satisfy the justice (Section 54) that the "water is so polluted, or likely to be so polluted, as to be injurious or dangerous to health."

In **Scotland**, according to Section 16 of the Public Health (Scotland) Act, 1897, any well or water-supply injurious or dangerous to health is a nuisance, and can be dealt with summarily as such. There is no power similar to that conferred on English sanitary authorities by the Public Health (Water) Act, 1878, to prevent a new house being occupied without a proper water-supply.

Section 125 of the Act of 1897 empowers every local authority, other than the local authority of a burgh, to require the owner to obtain such supply within a reasonable distance, and failing compliance, within twelve months after due notice, the authority may themselves obtain such supply and recover the expenses, or if the owners of two or more houses have failed to comply with notice, the authority may provide a joint supply and apportion and recover the expenses, subject, however, to appeal to the sheriff of the county, whose decision shall

be final ; but nothing in this section relieves the local authority from the duty of providing their district, or any part thereof, with a supply of water, where a general scheme for such a supply is required and can be carried out at a reasonable cost.

Section 126 of the 1897 Act gives full power, under the Lands Clauses Acts, to every local authority, other than that of a burgh, to provide a public supply, or contract, or arrange with any other person furnishing the same except within any area which any local authority, or any company established by Act of Parliament or empowered by provisional order is authorised to supply with water, unless the local authority shall previously have purchased or acquired the existing undertaking. Section 127 provides against pollution of sources of public supplies, and imposes penalties, while Section 130 gives power to local authorities to combine for the purposes of providing public water-supplies or acquiring an interest in any existing supplies subject to the sanction of the Local Government Board. Upon requisition to this effect by a parish council, or by ten or more ratepayers within the district, the local authority, other than that of a burgh, is bound by Section 131 to consider the propriety of forming part of their district into a special water-supply district, or of enlarging or limiting the boundaries thereof, or of combining water-supply districts, or determining that any water-supply district shall cease to exist as such, or that any such combination shall cease. The resolution of the local authority determines all questions of payment or assessment, on due notice being given, subject to the decision or order of the sheriff of the county, and it is not competent to appeal to the County Council against any resolution of a committee under this section. Section 132 provides that the local authority is not obliged to furnish a supply of water to any person for any less sum than five shillings yearly, nor is any person entitled to demand such supply unless some pipe of the local authority is laid within 100 feet of the premises, and the supply need not be constant.

Water-supplies for burghs may be obtained under the Public Health (Scotland) Act, 1867, the Public Health Amendment Acts, 1882 and 1891, or the Burgh Police Act, 1892, as in landward districts, proceeding by provisional order where any compulsory clauses are necessary, but the local authority, although it may purchase or contract, may not enter into competition with any existing water company. Under the Burgh Police Act, 1892, the burgh commissioners of towns with a population below 5000 may apply the compulsory clauses of the Lands Clauses Acts with the consent of the sheriff only, and

without a provisional order. In a burgh the owner may be compelled to convey the water into his house.

In **Ireland,** every sanitary authority, whether urban or rural, is empowered by Section 61 of the Public Health (Ireland) Act, 1878, to provide their district or any contributory place therein, or any part of such place, with a proper and sufficient water-supply, or to lease, hire, purchase water-works, or contract for a public supply, but so as not to interfere with the rights of any water company; while Section 202 endows them with compulsory powers to acquire water rights. Section 72 empowers all sanitary authorities to require that any house within their district without a proper supply shall be supplied at such cost as the Local Government Board may, under all the circumstances, determine to be reasonable, and failing compliance with notice they may themselves provide the supply and recover the costs. The law as to water-rates is similar to that in England, except that the levying of such rates is optional, or they may agree with any person and charge by meter (Sections 66-68). Similar powers are conferred against pollution of sources of public supplies by Sections 77 and 78, and for closing a well, etc., "if it is so polluted as to be injurious to health," by Section 79.

IX.—Nuisances

Nuisances are classed as of two principal kinds, namely, those which can be dealt with at common law, and those generally designated "statutory nuisances," which can be dealt with under the Public Health and other Sanitary Acts. Such statutory nuisances, according to legal decisions, include "all those which, though they may not actually have caused injury to health, are such as to interfere with the comfort of life, and may probably become injurious to health."

The provisions of the Public Health Act, 1875, relating to England and Wales, are embraced in Sections 91-111 of the Act. They apply to every urban and rural sanitary

district, and, according to Section 111, "are deemed to be in addition to, and not to abridge or affect any right, remedy, or proceeding under any other provisions of the Act, or under any other Act, or at law or equity"; but no person can be punished for the same offence under these provisions, and under any other law or enactment. It will be seen from the definition of "nuisance" given below that it embraces some nuisances which, as has already been shown, come under other sections of the Act, as, for example, sewers (Sections 18 and 19); drains, closets, ash-pits, and cess-pools (Sections 40 and 41); neglect of scavenging and cleansing (Sections 42-46); pig-styes, water in cellars, or the overflow or soakage from privies and cess-pools (Section 47). For dealing with these nuisances remedies are provided under other sections of the Act, more particularly under Sections 41, 49, and 50, and it will rest with the sanitary authority and their officials, under which provisions they will proceed, having regard to all the circumstances presented by individual cases.

1. *Definition of Nuisances.* — Section 91 defines the following to be nuisances:—

(1) Any premises in such a state as to be a nuisance or injurious to health:

(2) Any pool, ditch, gutter, watercourse, privy, urinal, cess-pool, drain, or ash-pit so foul or in such a state as to be a nuisance or injurious to health:

(3) Any animal so kept as to be a nuisance or injurious to health:

(4) Any accumulation or deposit which is a nuisance or injurious to health:

(5) Any house or part of a house so overcrowded as to be dangerous or injurious to the health of the inmates, whether or not members of the same family:

(6) Any factory, workshop, or workplace not kept in a cleanly state, or not ventilated in such a manner as to render harmless as far as practicable any gases, vapours, dust, or other impurities generated in the course of the work carried on therein, that are a nuisance, or injurious to health, or so overcrowded while work is carried on, as to be dangerous or injurious to the health of those employed therein:

(7) Any fireplace or furnace which does not as far as practicable consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing

or trade process whatsoever; and any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance, shall be deemed to be nuisances, liable to be dealt with summarily in manner provided by this Act: Provided—

First. That a penalty shall not be imposed on any person, in respect of any accumulation or deposit necessary for the effectual carrying on of any business or manufacture, if it be proved to the satisfaction of the court that the accumulation or deposit has not been kept longer than is necessary for the purposes of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health:

Secondly. That where a person is summoned before any court in respect of a nuisance arising from a fireplace, or furnace, which does not consume the smoke arising from the combustible used in such fireplace or furnace, the court shall hold that no nuisance is created within the meaning of this Act, and dismiss the complaint, if it is satisfied that such fireplace or furnace is constructed in such manner as to consume as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having the charge thereof.

The sanitary defects implied in sub-section (1) have reference, for the most part, to the cleansing or white-washing of dirty houses; the repair of roofs that let in the rain; the repair of walls and uneven floors; the opening of fastened windows to improve the ventilation; the repair of closets; the relaying of defective drains; the ventilation, trapping, or disconnection of house-drains; the removal of privies or middens near houses or wells; the prevention of dampness as far as possible; the cleansing and repair of yards, courts, and paving; and, especially in rural districts, the sanitary improvement of farm-yards adjoining the dwellings. The filthy, sloppy condition of many of these yards is often caused by want of proper spouting to the farm-buildings, as well as defective drainage; and another common source of nuisance, connected with them, is the proximity of the offensive pig-wash cistern to the farm-house.

As will be shown subsequently, Section 97 gives power to close a house when from its dilapidated condition or dampness of site, etc., it becomes unfit for human habitation,

so that the notice may either be to repair or close, as circumstances indicate.

(2) This sub-section requires no further comment than this, that whenever any offensive smell is given off, by any pool, ditch, etc., whether it be in the proximity of dwellings, or near any frequented road or footpath, there is sufficient evidence of the existence of a nuisance which calls for removal. And here it may be pointed out that (under Section 8 of the Local Government Act, 1894, every parish council is empowered to deal with "any pond, pool, open ditch, drain, or place containing or used for the collection of any drainage, filth, stagnant water, or matter likely to be prejudicial to health, but so as not to interfere with any private right or the sewage or drainage works of any locality." This power, however, does not relieve sanitary authorities from their obligations to abate nuisances of this description).

(3) This sub-section applies to pig-styes, fowl-pens, dog-kennels, cow-byres, etc. In dealing with nuisances of this description, it often happens that the abatement may be effected in various ways. For example, a nuisance arising from a pig-stye may be abated sometimes by keeping the animal in a more cleanly way, by lessening the number of pigs, by properly draining the pig-stye, by removing the pig-stye, if it be too near a dwelling, or too near a frequented path, or by prohibiting the keeping of pigs altogether. It may safely be laid down as a rule, that pig-styes close to dwellings, or under bedroom windows, will always be more or less a nuisance, no matter how carefully the animal may be kept. In *urban* districts, bye-laws based on the Model Bye-Laws of the Local Government Board, prescribe a distance of from 60 to 100 feet from any dwelling-house. If several kinds of animals are kept in the same shed or yard, so as to create nuisance, notice for abatement may be given under sub-section (1).

(4) In this sub-section are included offensive manure-heaps or other filth-accumulations, which are close to dwelling-houses or frequented paths. It also applies to offensive refuse-heaps of every kind, with the proviso already

quoted in respect of any accumulation or deposit necessary for the carrying on of any business or manufacture.

(5) This sub-section throws considerable responsibility on the medical officer of health, as to what constitutes overcrowding. But a safe rule to follow is to adopt as a minimum the standard laid down in the Model Bye-Laws of the Local Government Board, namely, 400 cubic feet for single-room dwellings, and 300 for sleeping-rooms per adult, and allowing half these amounts for every child. In the interests of morality it is unfortunate that the definition was not extended so as to prevent grown-up children of both sexes sleeping in the same room, or in the same room with their parents.

(6) The provisions of this sub-section apply to all factories, workshops, or work-places in respect to cleanliness, ventilation, overcrowding, lime-washing, and freedom from nuisance generally.

(7) In order to obviate nuisance coming within this sub-section, all furnaces or factory fireplaces should have chimneys of sufficient height, and should be provided with smoke-consuming apparatus. Very often it is found that nuisance arises from neglect in stoking. By Section 334 it is provided that nothing in the Act shall be construed to extend to mines, smelting of ores and minerals, puddling of iron, etc.

(Amongst other nuisances the Quarry (Fencing) Act, 1887, provides that where any quarry, dangerous to the public in open or unenclosed land, is within 50 yards of a highway, or place of public resort, and is not kept reasonably fenced for protection against accident, it shall be deemed to be a nuisance liable to be dealt with summarily in manner provided by the Public Health Act, 1875. The Coal Mines Regulation Act, 1887, contains similar provisions with respect to the fencing of abandoned or discontinued coal mines.)

2. *Abatement of Nuisances.*—The following is a digest of the sections of the 1875 Act applying to obligations, procedure, and abatement:—

(1) It is the duty of every local authority to cause to be made from time to time inspection of their district with a view to ascertain what nuisances exist, and to enforce the provisions of this Act in order to abate the same (Section 92).

(2) Information of any nuisance under the Act may be given by any person aggrieved, by any two inhabitant householders, by any officer of the local authority, by the relieving officer, or by any officer of the police (Section 93).

(3) If satisfied of the existence of a nuisance, the local authority must serve a notice on the person responsible for the nuisance, or if such person cannot be found, on the owner or occupier of the premises on which the nuisance arises, requiring him to abate the same within a time to be specified in the notice, and to execute such works, and do such things as may be necessary for that purpose. When the nuisance arises from any want, or defective construction, of any structural convenience, or where there is no occupier, notice must be served on the owner; or if the person responsible for the nuisance cannot be found, and neither the owner nor occupier is responsible, the local authority may themselves abate the same without further order (Section 94).

(4) If the person on whom the notice is served fails to comply with any of its requisitions within the time specified, or if the nuisance though abated is likely to recur, the local authority must cause a complaint to be made before a justice, and such justice shall thereupon issue a summons requiring the person on whom the notice is served to appear before a court of summary jurisdiction (Section 95).

(5) If the court is satisfied that the alleged nuisance exists, or though abated is likely to recur, it shall make an order requiring compliance with any or all of the requisitions of the notice, or any order prohibiting recurrence of the nuisance, and directing the execution of any works necessary for abatement or prevention of recurrence. The court may further impose a penalty not exceeding five pounds, and shall also give directions as to the payment of costs (Section 96).

(6) When the nuisance is such as to render a house unfit for human habitation, the court may order the house to be closed until it is rendered fit for occupation, and when satisfied that it has been rendered habitable, the court may determine the previous order by a further order declaring the house to be habitable, after which it may be let or occupied (Section 97).

(7) Any person not obeying the order of the court, or who fails to use due diligence to carry out such order, is liable to a penalty not exceeding ten shillings per day during his default, or to a penalty not exceeding twenty shillings per day if he acts knowingly and wilfully contrary to an order during such contrary action. Further, the local authority may themselves execute the order, and recover the expenses incurred from the person on whom the order is made (Section 98).

Power of appeal, however, is granted to the Court of Quarter Sessions, and no penalty is incurred, nor can the order be executed until such appeal is heard or ceases to be prosecuted (Section 99).

(8) When the person responsible for the nuisance, or the owner or occupier, cannot be found, the order of the court for abatement may be addressed to and executed by the local authority (Section 100), and any matter or thing removed by the authority in abating any nuisance under this Act may be sold by public auction (Section 101).

(9) The local authority, or their officers, have rights of entry on any premises for the purpose of examination as to the existence of any nuisance thereon between the hours of 9 A.M. and 6 P.M., and in the case of nuisance on business premises, at any hour during which such business is carried on. If admission is refused, a justice's order for entry may be obtained (Section 102). Any person who refuses to obey such order is liable to a penalty not exceeding five pounds (Section 103).

(10) Complaint of nuisance may be made to a justice by any person aggrieved thereby, or by any inhabitant, or by any owner of premises, and upon such complaint the like proceedings detailed in the previous sections shall be taken as in the case of complaint made to a justice by a local authority, provided that the court may adjourn the hearing for examination of the premises. The court may also authorise a constable or other person to do all necessary acts to abate the nuisance, and to recover the expenses incurred from the person on whom the order is served in a summary manner, and such constable or authorised person shall have like powers of entry, and be under the like restrictions as if he were an officer of the local authority (Section 105).

(11) Where it is proved to the satisfaction of the Local Government Board that a local authority has made default in relation to the abatement of nuisances under this Act, the Board may authorise any officer of police within the district of the authority to institute proceedings for abatement, and may recover the expenses incurred from the defaulting authority. Such officer, however, has no power of entry without consent, or without the warrant of a justice (Section 106).

(12) Where a nuisance appears to be partially or wholly caused by some act or default outside the limits of their district, a local authority is nevertheless authorised to take proceedings for abatement in the same way as if the nuisance were caused entirely within their district (Section 108).

(13) Where two convictions for overcrowding in a house have taken place within three months, the Court of Summary Jurisdiction may, on the application of the local authority, direct the closing of the house for such period as the court may deem necessary (Section 109).

(14) In respect to nuisances, any ship or vessel, not under the command of any officer bearing Her Majesty's Commission, or belonging to any Foreign Government, lying in any harbour, river, or

water within the district of any local authority, is subject to the jurisdiction of the authority as if it were a house. If lying in any harbour, or water not within their district, it shall be deemed to be within such district as the Local Government Board may direct, and where no local authority has been prescribed, then within the nearest district (Section 110).

In **London,** the duties, powers, and obligations of the sanitary authorities in respect to nuisances and their abatement are similar to those already described, except that in Section 2 of the Public Health (London) Act, 1891, the definition of "nuisance" is extended to include not only that which is injurious, but also that which is dangerous, to health. In connection with premises, a nuisance also includes any cistern, water-closet, or dung-pit, "so foul or in such a state as to be a nuisance or injurious or dangerous to health," and any such absence from premises of water-fittings as is a nuisance, by virtue of Section 33 of the Metropolis Water Acts, 1871.

Section 3 of the 1891 Act provides that while information of a nuisance may be given by any person to the sanitary authority, it is made the duty of every officer of the authority and every relieving officer so to do, and also to give written notice to the person who may be required to abate it, but it is optional in giving notice to specify the works to be executed.

Section 4 of the Act also provides that where the person causing the nuisance cannot be found, the sanitary authority may themselves abate the nuisance, and do what is necessary to prevent its recurrence, and in cases of overcrowding certified by the medical officer of health, the authority are bound to take proceedings to abate the nuisance. The penalty incurred for wilful nuisance or non-compliance with notice is a fine not exceeding £10 for each offence. Legal proceedings are on lines similar to those laid down in the Public Health Act, 1875.

Section 16 of the London Act renders it obligatory on every sanitary authority to make bye-laws with respect to the prevention of nuisances arising from—(1) snow, dust, ashes, filth, etc., in any street; (2) from any offensive matter running from any manufactory, slaughter-house, etc.; (3) from keeping of animals; and (4) as to the paving of yards and open spaces in connection with dwelling-houses. Further, it is made the duty of every sanitary authority to observe and enforce the general bye-laws made by the County Council as to the cleansing of streets and prevention of nuisances, and a constable may arrest without warrant any person whom he finds committing an offence against any of these bye-laws if he refuses to give his name and address.

In relation to smoke-consumption, Section 23 of the London Act, 1891, provides that all furnaces in baths, wash-houses, mills, factories, bakehouses, water-works, etc., or other buildings used for trade or manufacturing purposes, or steam vessels plying on the river west of the Nore, must be constructed so as to consume their own smoke. It is made the duty of every sanitary authority to carry out the provisions of this section, but no information may be laid for the recovery of any fine except under the direction of a sanitary authority. The section extends to the Port of London, and it must be enforced by the city corporation as the port sanitary authority.

In **Scotland,** the definition of "nuisance," according to Section 16 of the Public Health (Scotland) Act, 1897, is similar to the definition given in the 1891 London Act, but the statutory enumeration of nuisances is more comprehensive than that given either in the London Act or the Public Health Act, 1875. The additions are briefly as follows:—

Any premises *or part thereof of such a construction* or in such a state as to be a nuisance; any well or water-supply injurious or dangerous to health; any deposit of offensive matter (other than farm-yard manure or spent hops from breweries) within 50 yards of any public road, or standing at any railway station, siding, or in canal boats, which is a nuisance; any schoolhouse, or any factory not subject to the Factory and Workshops Acts, 1878 and 1895, which is a nuisance with respect to cleanliness, ventilation, and overcrowding; and any churchyard or cemetery so situated or so crowded, or otherwise so conducted, as to be offensive or injurious or dangerous to health.

Section 18 of the Act gives full powers to the sanitary local authority or their officers to enter and inspect any premises where they have reasonable grounds for believing that a nuisance exists, within the hours of 9 A.M. and 6 P.M., or when any operations causing the nuisance are in progress. They may then open up the ground, or test the drains, or do what is necessary for an effectual examination of the premises, provided that, if no nuisance is found to exist, the authority shall restore the premises at their own expense. If admission is refused, the local authority or their officers may apply to the sheriff, magistrate, or justice of the peace having jurisdiction in the district, for an order for admission, and refusal to obey this order incurs a liability of a fine not exceeding £5.

Section 22 provides that except in respect to fireplaces, furnaces, and chimneys sending forth smoke so as to be a nuisance, and also churchyards and cemeteries, as regards all of which application must be made to the sheriff, the summary decision of the sheriff, magistrate, or justice upon the alleged nuisance is final. This section further provides that as regards nuisance connected with manufactories, trades, or businesses, or any collection of bones or of rags, a medical certificate,

or a written requisition signed by ten ratepayers of the district, is required before proceedings can be taken. Under Section 25 the sheriff, magistrate, or justice may order the necessary works to be carried out for the abatement of nuisance, and before making the order may require the local authority to furnish an estimate of the cost. Such order may also ordain the local authority to abate the nuisance and recover the expenses from the person responsible for the nuisance, or if the owner cannot be found, do the necessary work.

For the abatement of other nuisances Section 28 provides that a local authority may, and shall if necessary, sewer any watercourse, ditch, or gutter, to abate nuisance, and, subject to the approval of the Local Government Board, may extend such sewer outside the limits of their district. Section 29 provides that they may erect public ash-pits, water-closets, privies, and urinals, and scavenge them ; and further, that they may require, by written notice to the owner or occupier of any schoolhouse, factory, or other place of business, to construct a sufficient number of water-closets or privies for the separate use of each sex, and failing compliance a penalty not exceeding £20 is incurred. Section 30 renders any one liable to a penalty not exceeding £5 who wilfully damages any sanitary convenience or fittings, while Section 31 imposes penalties, with respect to wilful damage to, or nuisance found to exist in connection with, conveniences or their fittings used in common, of 10s. and 5s. respectively.

If a local authority neglects or fails to carry out the provisions of the Act, in respect to nuisances or otherwise, Sections 146-148 provide that any ten ratepayers residing in the district, or a parish council, or the procurator fiscal, may apply to the sheriff for a summary decree if the authority fail to comply within fourteen days with written notice ; or if the Local Government Board are satisfied that a local authority has made default, the Board may, with the approval of the Lord Advocate, institute proceedings.

In **Ireland,** the definition and statutory enumeration of nuisances, as well as mode of procedure in respect to abatement, as set forth in Sections 107-127 of the Public Health (Ireland) Act, 1878, are practically identical with the provisions of the Public Health Act, 1875, already detailed, with the unimportant exception that while the Coal Mines Regulation Act, 1887, applies to Ireland, the Quarry Fencing Act does not apply.

X.—Offensive Trades

By Section 112 of the Public Health Act, 1875, offensive trades are defined as those of " blood-boiler, bone-boiler, fell-

monger, soap-boiler, tallow-melter, tripe-boiler, and any other noxious trade, business, or manufacture," and the same section renders it illegal to establish any of these offensive trades within an *urban* district without the written consent of the sanitary authority.

As regards the prohibition of the establishment of offensive trades generally, it will devolve upon the *urban* authority to show that the trade is either one of those specially mentioned, or that it comes under the same category, and that it is essentially an offensive trade, apart altogether from mismanagement. In commenting upon this section, Lumley remarks that it is impossible to enumerate the various trades which may be noxious or offensive within its meaning; nor do the cases in which the courts have interfered afford any guidance in the determination of the question, for a trade not noxious may be so conducted as to be an actionable nuisance—as in the case of brick-burning. Nevertheless, a large number of offensive trades, which may not come within the above restriction, can be dealt with under Section 114 as follows:—

Where any candle-house, melting-house, melting-place, soap-house, slaughter-house, or any building or place for boiling offal or blood, or for boiling, burning, or crushing bones; or *any* manufactory, building, or place used for any trade, business, process, or manufacture causing effluvia, is certified by the medical officer of health, or by any two medical practitioners, or by any ten inhabitants of the district, to be a nuisance or injurious to health, it becomes the duty of the *urban* authority to take proceedings, and the person so offending becomes liable to a penalty not exceeding £5 nor less than 40s., unless he can show that he has adopted the best practical means for abating such nuisance or mitigating or preventing the injurious effects of such effluvia; or the authority, if they think fit, may institute proceedings in any superior court of law or equity for the abatement of the nuisance so certified. Under Section 115 power is also given to an *urban* authority to institute proceedings on such certificate in the case of a trade nuisance affecting the inhabitants of their district though the nuisance arises without the district, and the section extends this power to vestries within the metropolitan area. Further, every *urban* sanitary authority is empowered to make bye-laws in respect to such offensive trades as have been established in their district with their

consent (Section 113), but in order to apply these provisions in a *rural* district, the authority would have to apply to the Local Government Board for *urban* powers under clause 276 of the Act.

In addition to the six trades specifically mentioned above, the Model Bye-Laws issued by the Local Government Board contain bye-laws affecting the following trades:—*blood-drier, leather-dresser, tanner, fat-melter* or *fat-extractor, glue-maker, size-maker,* and *gut-scraper.* Without entering into details, these bye-laws provide for the conveyance and storage of foul and offensive materials in properly-constructed vessels or receptacles covered with tight-fitting lids; for cleanliness of premises by requiring the construction of impervious floors and walls where necessary, by washing the same daily if required, and lime-washing parts of walls, not cemented or otherwise rendered impervious, as well as ceilings, at least twice a year; for effectual drainage, and the cooling of all hot liquid refuse before discharging into any drain; for the removal of all waste material without creating nuisance; and, above all, for the adoption of the best practicable means for rendering all vapours given off in the process of trade or manufacture innocuous. In dip candle-making or fat-melting, the fat is melted either in pans heated by an open fire, by free steam and sulphuric acid, or in steam-jacketed pans. Melting by an open fire is always productive of great nuisance, unless the vapours are consumed by fire supplied with air from the top of the pan, and this necessitates a strong draught, such as can only be obtained by a high chimney-shaft. In populous neighbourhoods, the only method which can be carried on successfully without nuisance is melting by free steam, or in steam-jacketed pans with close-fitting covers, and even then, the vapours must be passed through a condensing apparatus, and afterwards, if necessary, through the furnace fire, or a fume-cremator.

According to Dr. Ballard, offensive gases or vapours, when drawn off or collected, may be dealt with in five different ways:—"(1) They may be discharged into the atmosphere at such an elevation as that they shall be so

diluted before reaching the ground as not to be offensive. When this will not suffice, other means must be used. (2) If the evolved matters be condensible by cold, they may be passed through an appropriate condensing apparatus. (3) If soluble in water, they may be submitted to the action of water in an appropriate apparatus, or similarly, to the action of any other liquid better calculated to absorb them. (4) Sometimes, in like manner, solid substances, with which the effluvia have chemical affinity, may be used with advantage, either in powder or otherwise. (5) If the evolved matters be combustible, they may be burned by conducting them through a fire" (*Supplement to Local Government Board Report*, 1876).

Gas-works often give rise to nuisance, especially in small towns or villages, where the process of manufacture and purification is imperfectly carried out. In addition to lime-purifiers, there should always be purifiers containing oxide, or other salt of iron, to remove the sulphuretted hydrogen. Usually, however, only lime-purifiers are employed, and the lime in these is so seldom changed, that not only is there intolerable nuisance produced when the purifiers are emptied, but the spent lime is so saturated with sulphuretted hydrogen and other offensive effluvia, that it cannot be removed from the works, unless in properly covered carts or trucks, without creating further nuisance. The ammoniacal liquor from gas-works should be removed in properly covered tanks or barges.

Before a conviction can be obtained in respect to established trades, it will be necessary to prove to the satisfaction of the court that the best practicable means for the abatement of nuisance have not been adopted; and as the medical officer of health is liable, in most cases, to be called upon to give skilled evidence, it is necessary that he should be well acquainted with the process of manufacture, or the details of the trade complained of, the nature of the effluvia given off, and the best means which should be adopted to prevent nuisance. Such knowledge can, of course, only be obtained by making himself well acquainted

with trade processes generally, and it must necessarily be supplemented by a thorough acquaintance with practical chemistry. Unless the medical officer of health is an expert in these matters, the best course to pursue is to recommend the manufacturer or tradesman, against whom complaint is made, to call in some competent person to advise him as to what steps he should take to prevent nuisance; and he should also recommend the sanitary authority to consult an expert, who would give evidence before the magistrates if necessary. (For special information on trade nuisances generally see Dr. Ballard's Reports to the Local Government Board, and Wynter Blythe's *Manual of Public Health*. See also page 103.)

In **London,** the provisions in respect to offensive trades are somewhat more stringent than those applying to England and Wales.

Section 19 of the Public Health (London) Act, 1891, Sub-section (1), prohibits, under a penalty not exceeding £50 per day, the establishing anew of the business of a blood-boiler, a bone-boiler, a manure manufacturer, a soap-boiler (if animal fats are used), a tallow-melter, or a knacker, but under Sub-section (4) old established businesses of the kind are permitted to continue subject to the bye-laws of the County Council. A new soap business may be established, if olein or other vegetable fat or oil is used (Sub-section 2), and certain other offensive businesses may also be established subject to the consent of the County Council, namely, those of fell-monger, tripe-boiler, slaughterer of cattle or horses, or any other business which the council may declare by order, confirmed by the Local Government Board to be offensive. According to Sub-section (8), establishing "anew" means reopening after discontinuance of works for nine months, removal to new premises or enlargement of existing premises, but no change of ownership, or reconstruction, partial or complete, without extension of area. The granting of sanction by order of the County Council of any new offensive trades is rendered subject to the proviso, Sub-section (3), that at least fourteen days before making such order they notify to the authority concerned that an application has been made, in order to give the inhabitants an opportunity of being heard at the necessary public inquiry.

Sub-section (4) of Section 19 empowers the County Council to make bye-laws for regulating the conduct of any of these businesses and structure of premises; (5) provides that any such bye-law may empower the court to deprive any person, either temporarily or permanently, of the right of carrying on the business on breach of the

bye-laws, and non-compliance with the order incurs a daily penalty not exceeding £50 ; while (6) provides that any sanitary authority, or person aggrieved by any proposed bye-law, or alteration or repeal of a bye-law, may forward notice of objection to the Local Government Board for consideration. Sub-section (9) exempts the Metropolitan and Deptford cattle-markets from the operation of any such bye-laws or order.

Section 20 of the Act prohibits the use of a slaughter-house, knackers' yard, or cow-house, and the businesses relating thereto, without an annual license from the County Council under a penalty not exceeding £5, but such licenses do not extend to the cattle-markets which come under the Metropolitan Market Acts, 1851 and 1857.

Under Section 22 the removal, collection, and deposit of house or street refuse by a sanitary authority is deemed to be an offensive trade ; and any premises used by a sanitary authority for the treatment or disposal of such refuse, which are a nuisance, may be dealt with summarily under the Act on proceedings being taken by the County Council as if the council were a sanitary authority.

The procedure for abatement provided by Section 21 of the Act is similar to that embodied in Sections 114 and 115 of the Public Health Act, 1875, already referred to.

In **Scotland,** the offensive trades classified under Section 32 of the Public Health (Scotland) Act, 1897, are the businesses of—

"Blood-boiler, bone-boiler, manure manufacturer, soap-boiler, tallow-maker, knacker, tanner, tripe-boiler, gut or tripe cleaner, skinner or hide factor, slaughterer of cattle or horses, or any other business which the local authority may declare, by order confirmed by the Local Government Board, to be an offensive business," and Sub-section (1) also prohibits the establishment of any such business without the sanction of the local authority, under a daily penalty not exceeding £25. Sub-section (2) provides that the sanction must be by order of the local authority, but public notice of the application for it must be given fourteen days before the order is issued, and where the local authority grants or withholds such sanction, any person aggrieved may appeal to the Local Government Board, but in the case of a district, other than a burgh, the appeal to the Board shall only arise after the County Council has given its determination on the matter, and a local authority may appeal against the determination of the County Council.

Sub-section (3) of the above section empowers the local authority to make bye-laws for the regulation of such businesses and the structure of premises, under penalties, and in addition may empower the sheriff to prohibit any person from following any business to which they apply on breach of them, but his order shall be subject to appeal to the Lord Ordinary. Under Sub-section (6) a newly-established business includes removal to other premises, or renewal on the same

premises after twelve months, or enlargement of the premises, but it does not include change of ownership or occupancy, or change or reconstruction of premises without extension of area.

Section 33 provides, as in the London Act, for the annual licensing of slaughter-houses and knackers' yards, but twenty days' public notice must be given before any new license is granted, and any person interested may show cause against the grant or renewal of the license. Sub-section (7) of this section gives power to appeal to the Local Government Board against refusal to grant or renew license, and such decision of the Board is final, but in the case of a district, other than a burgh, the appeal to the Board can only arise after the determination of the County Council, and the local authority may appeal to the Board against such determination.

Section 34 of the Act empowers the local authority of any district, other than a burgh, or two or more such authorities, to provide public slaughter-houses, and to borrow any necessary sums on the security of the public health general assessment of the district or districts concerned.

Section 35 empowers every local authority to make bye-laws regulating the construction of pig-styes, the places in which they may be erected, and their scavenging.

Section 36 gives power on certificate of the medical officer of health, or written requisition of a parish council, or of the ratepayers in a district, to take proceedings before the sheriff court, but it is optional on the part of the sanitary authority to proceed unless required to do so by the Local Government Board. The sheriff may impose a penalty of £50 on conviction, or may suspend judgment until the offender has carried out any works or alterations which may be deemed necessary for the effectual abatement or mitigation of the nuisance complained of; or the local authority, if they think fit, may cause proceedings to be taken in the Court of Session instead of in the sheriff court in the first instance.

Section 37, as in the London Act, designates the collection and removal of house or street refuse to be a trade nuisance, whether carried on by a local authority or a contractor, and both in respect to this or any premises used for the treatment or disposal of such refuse in any district, which become a nuisance, proceedings may be taken by the County Council of the district, other than a burgh, or by any person authorised by the Board in like manner as if such County Council or such person were a local authority.

In burghs, the commissioners or local authority have power to make bye-laws for reducing or removing the noxious or injurious effects of these offensive trades under Section 316 of the Burgh Police (Scotland) Act, 1892.

In **Ireland**, the business of a gut-scraper is added to the list of offensive trades included in the English Act, 1875,

by Section 128 of the Public Health (Ireland) Act, 1878, but as a rural authority cannot be vested with urban powers as in England, only urban authorities can prevent the establishment of offensive trades in their districts. On certificate of their medical officer of health, or of two qualified medical practitioners, or on the requisition of ten ratepayers, urban sanitary authorities are bound, under Section 130 of the Act, to take proceedings, while Section 131 empowers them to take proceedings for any such nuisance affecting them which is created outside their district. In other respects, the provisions of the Act are similar to those contained in the 1875 English Act.

XI.—Alkali and Other Chemical Works

In addition to offensive trades dealt with as above, there is a large number of other trades or businesses which give off noxious and offensive gases, and are subject to the provisions of the Alkali, etc., Works Regulation Acts of 1881 and 1892. These Acts apply not only to alkali works, but also to sulphuric acid works, nitric acid works, chlorine works, bleaching powder or liquor works, chemical manure works, sulphate of ammonia works, muriate of ammonia works, venetian red works, lead deposit works, arsenic works, nitrate and chloride of iron works, fibre separation works, tar works, zinc works, and also the following, unless no sulphuretted hydrogen is evolved, namely, alkali waste works, barium works, strontium works, antimony works, and bisulphide of carbon works. All these works must be registered annually, and are under the supervision of special inspectors appointed by the Local Government Board (Section 11 of the 1881 Act), and Section 12 provides that no new work can be registered unless furnished with satisfactory and proper appliances.

Section 3 of the 1881 Act requires that in all alkali works 95 per cent of the hydrochloric acid evolved must be condensed, and not more than one-fifth of a grain of hydrochloric acid per cubic foot of air, smoke, or chimney gases, must escape from the works into the atmo-

sphere; nor must there be more of the acid gases of sulphur and nitrogen than the equivalent of four grains of sulphuric acid per cubic foot. In calculating the proportion of acid, Section 21 enjoins that the basis of calculation is to be a temperature of 60° F., with a barometric pressure of 30 inches.

Acid drainage must not be allowed to mix with acid waste so as to cause a nuisance, and the owner may require the sanitary authority to provide and maintain a drain, at his expense, for carrying the acid waste into the sea, or any watercourse into which it can be taken without breach of the Rivers Pollution Act, 1876 (Section 5). No alkali waste must be deposited or discharged without the best practicable means being adopted to prevent nuisance (Section 6).

Similar regulations and penalties for infringement apply to sulphuric acid works, and the gases escaping into the atmosphere must not have an acidity equivalent to more than four grains acidity per cubic foot (Section 8). With regard to the other works scheduled in the Acts, Section 9 provides that the best practicable means must be employed for preventing the escape of noxious and offensive gases, and for rendering them harmless and inoffensive. Section 27 empowers any sanitary authority to complain to the Local Government Board on the written representation of ten ratepayers or the certificate of their officers that any work either within or without their district, to which these Acts apply, is carried on in contravention to them, and the Board may direct such proceedings to be taken by an inspector as they see fit. Section 31 further provides that nothing in these Acts is to be construed as legalising any act or default which would otherwise be deemed a nuisance, or contrary to law, had these Acts not been passed.

The Acts apply to Scotland and Ireland as well as to England and Wales, and the central authorities are the respective Local Government Boards.

XII.—Factories, Workshops, and Bakehouses

The Acts which relate to these places are the Factory and Workshop Acts of 1878, 1883, 1891, and 1895, and they apply to England and Wales, London, Scotland, and Ireland. Section 91 of the Public Health Act, 1875 (see *ante*, p. 630), refers to the conditions in which any factory or workshop may be dealt with as a nuisance, but according to Section 61 of the Factory and Workshop Act, 1878, this section of the 1875 Act only applies to "a private house, room, or place which, although by reason of the work

carried on there is a factory, is used as a dwelling, and in which neither steam, water, nor other mechanical power is used, and in which the only persons employed are members of the same family dwelling there."

The Acts are very complex, but speaking generally, they make sanitary authorities responsible for the sanitary condition of workshops, while factories are for that, as well as other purposes, under the supervision of the Factory Inspectors appointed by the Home Office. According to Dr. Whitelegge, Chief Inspector of Factories, the broad line of distinction between factories and workshops is the use of mechanical power—the former being works in which power is used, and technically a few kinds are so classed whether power be used or not. For example, by the Act of 1895, Section 22, steam laundries are classed as factories, and other laundries as workshops; but the law only applies to laundries carried on for purposes of trade or gain, and not where the persons carrying on the laundry are members of the same family. The Acts are largely concerned with matters which only concern the factory inspectors, but the provisions which chiefly concern health are the following:—

All *factories* and *workshops* must be kept clean and free from effluvia arising from any drain, closet, urinal, or other nuisance. By Section 1 of the 1895 Act, a minimum air space of 250 cubic feet, and 400 during overtime, is required for every person; and the Home Secretary has power to add to this minimum during hours in which artificial (not electric) light is employed. Factory inspectors have power to require that a reasonable temperature must be maintained, and that workplaces must be so ventilated by fans, if necessary, as to render harmless, as far as practicable, gases, vapours, dust, or other impurities generated in the work and injurious to health. For the sanitary supervision of these places, the factory inspectors have exceptional powers of entry, inspection, and of taking legal proceedings.

With regard to workshops, as distinguished from factories, it is pointed out in a circular issued by the Local Government Board in 1891, that the provision contained in Section 91 of the Public Health Act, 1875, in respect to cleanliness, ventilation, and overcrowding, is applicable to workshops generally, and it is the duty of the sanitary authority to enforce that provision accordingly.

Section 4 of the 1878 Act, as amended by Section 2 of the 1891 Act, and Section 3 of the 1895 Act, renders it incumbent on a factory

inspector when he deems that there is any act or default relating to sanitary condition or other requirements in a factory or workshop, which is punishable or remediable under the Public Health Act, 1875, but not under the Factory or Workshop Acts, to give notice of the same to the sanitary authority; and it then becomes the duty of the sanitary authority to make such inquiry and take such action, within one month, as may be proper for the enforcement of the law, and to notify to the inspector the proceedings taken. In case of default on the part of the authority, the inspector may himself take proceedings, and recover expenses from the sanitary authority.

In most factories, the walls and ceilings must be cleansed every fourteen months, but in workshops this is only compulsory when ordered by the sanitary authority on certificate of the medical officer of health or sanitary inspector that it is necessary for the health of the workers, and the owner or occupier becomes liable to a daily penalty of ten shillings for non-compliance with notice (Section 4 of the 1891 Act; and in respect to London, Sections 25 and 26 of the Public Health (London) Act, 1891).

Section 5 of the 1895 Act prescribes a penalty of ten pounds for employment of persons in places, not necessarily a factory or workshop in the meaning of the Acts, which are injurious or dangerous to health; while Section 6 prescribes a like penalty "if any occupier of a factory, workshop, or laundry, or of any place from which work is given out, or any contractor employed by such occupier, causes or allows wearing apparel to be made, cleaned, or repaired in any dwelling-house or dwelling occupied therewith whilst any inmate of the dwelling-house is suffering from scarlet fever or small-pox."

Section 29 of the 1895 Act provides that "every medical practitioner attending or called in to attend a patient whom he believes to be suffering from lead, phosphorus, or arsenical poisoning, or anthrax contracted in any factory or workshop," must notify the case forthwith to the Chief Inspector of Factories, Home Office, and is entitled to a fee of two shillings and sixpence for so doing, and for default is liable to a fine not exceeding forty shillings. The employer must also give notice of every such case to the factory inspector, and certifying surgeon of the district.

Section 30 of the 1895 Act requires proper washing conveniences where "lead, arsenic, or other poisonous substance is used."

The medical officer of health must give written notice to the factory inspector of the district if he finds that any child under fourteen years of age, or young person from fourteen to eighteen years, or woman, is employed in any workshop (Section 3 of the 1891 Act, and in respect to London, Section 27 of the Public Health (London) Act, 1891).

Section 35 of the 1895 Act enacts that "in every place where Section 22 of the Public Health Acts Amendment, 1890, is not in force, every factory and workshop shall be provided with sufficient

and suitable accommodation in the way of sanitary conveniences, having regard to the number of persons employed, with proper separate accommodation for each sex." (The minimum accommodation which is generally considered to be sufficient is one closet for each sex for every twenty persons up to one hundred.)

In respect to dangers from fire, Section 7 of the 1891 Act imposes the duty of providing adequate means of escape from fire upon sanitary authorities, and to give certificates to that effect before a new factory or workshop in which more than forty persons are employed can be legally occupied. Section 10 of the 1895 Act enables a factory inspector to require such means to be provided if they are deemed by him to be inadequate.

By Section 31 of the 1895 Act all textile factories in which the atmospheric humidity is artificially increased for trade purposes, and which are not for the time-being subject to special rules under Section 8 of the 1891 Act, come under the provisions of the Cotton Cloth Factories Act, 1889. According to this Act, notice of the adoption of such practice must be given to the Chief Inspector of Factories. Arrangements must be made for the admission of at least 600 cubic feet of fresh air per occupant per hour. There must be two sets of standard wet- and dry-bulb thermometers provided and maintained in working order, and so placed as to be in full view of the operatives. Daily readings are to be taken between 10 and 11 A.M., and again between 3 and 4 P.M., and records kept. A schedule of the Act specifies among other details, for each dry-bulb temperature a maximum permissible reading of the wet bulb ; and a copy of this table must be placed near each hygrometer. The temperature must not be raised above 70° F. In workshops or factories where wearing apparel is made, the temperature must be maintained at not less than 60° F.

Under Section 8 of the 1891 Act, the Home Secretary is empowered to certify industrial processes as dangerous to life or health, and in respect to these, the chief inspector may prescribe special rules, or the adoption of precautionary measures. The following processes have been so scheduled :—The manufacture of white lead, paints, and colours ; the extraction of arsenic ; the enamelling of iron plates ; the manufacture of lucifer matches, except such as are made with red or amorphous phosphorus ; the manufacture of earthenware ; the manufacture of explosives in which di-nitro-benzole is used ; chemical works ; quarries ; the manufacture of red, orange, or yellow lead ; lead smelting ; the tinning and enamelling of iron hollow ware ; electric accumulator works ; flax mills and linen factories ; brass mixing and casting ; the tinning and enamelling of metal hollow ware and cooking utensils ; and processes in which yellow chromate of lead is used, or in which goods dyed with it undergo treatment.

Bakehouses.—For the purposes of the Factory and Workshop Acts, bakehouses are classed as "wholesale" or

"retail." Wholesale bakehouses are to be regarded as factories, while a "retail" bakehouse is defined by Section 18 of the 1883 Act as meaning "any bakehouse or place, the bread, biscuits, or confectionery baked in which are not sold wholesale but by retail, in some shop or place occupied together with such bakehouse." The sanitary supervision of these retail bakehouses is entrusted to urban and rural authorities throughout England, Scotland, and Ireland; to the vestries and district boards in London; and to the Commissioners of Sewers in the city.

Section 27 of the 1895 Act extends to all bakehouses the provisions of Sections 34 and 35 of the 1878 Act, whether in towns or rural districts, which are as follows:—All the inside walls, ceilings, passages, and staircases either painted or varnished or lime-washed, or partly painted or varnished and partly lime-washed,—if painted or varnished they must have three coats of paint or varnish, and be washed with hot water and soap every six months, and where lime-washed, the lime-washing shall also be renewed every six months. No place on the same level as a bakehouse shall be used as a sleeping-place, unless it is effectually separated from the bakehouse by a partition extending from floor to ceiling, and unless it has an external window 9 feet square, half of which is made to open. The fine for not keeping a bakehouse in conformity with these provisions is a penalty not exceeding £10.

Sections 15 and 16 of the Factory Act, 1883, as amended by Section 27 of the 1895 Act, render it illegal to let or occupy as a bakehouse any room or place, unless the following conditions are complied with:—(1) No water-closet, earth-closet, privy, or ash-pit shall be within or communicate directly with the bakehouse; (2) any cistern supplying water to the bakehouse must be separate from any cistern supplying a water-closet; (3) no drain or pipe carrying off sewage shall have an opening within the bakehouse. Any one offending against these provisions is liable to a penalty not exceeding 40s., and a further fine of 5s. for every day during which any room or place is used in contravention of the provisions after a conviction.

By Section 27 (3) of the 1895 Act, no place underground may be used as a bakehouse unless so used before 1st January 1896, and if so used must not be in contravention of the above conditions.

The supervision of bakehouses devolves in special degree upon the medical officer of health. By Section 18 of the Factory Act, 1878, he is invested with all the powers of entry, inspection, and taking legal proceedings possessed by a factory inspector. He is also required to give written notice to the factory inspector of the district if he becomes aware of the employment of any child or young person under

eighteen years of age, or woman, in any retail bakehouse. Section 68 of the 1878 Act, and Sections 25 and 39 of the 1891 Act empower him to enter, inspect, and examine any bakehouse at any reasonable time, day or night, without any special written authority or warrant.

In all proceedings for fines, the information must be laid within two months, or within three months where the offence is punishable by imprisonment, but there is power of appeal to the higher courts (Sections 89, 90, 91 of the 1878 Act).

XIII.—Slaughter-Houses and Market-Places

According to Section 4 of the Public Health Act, 1875, the expression "Slaughter-House" includes the buildings and places commonly called slaughter-houses and knackers' yards, and any place or building used for slaughtering cattle, horses, or animals of any description, for sale.

Sections 166-168 of the 1875 Act empower *urban* authorities to provide market-places, purchase or lease land for the purpose, furnish all necessary appliances and equipments, and make bye-laws for the regulation of such market-places.

Section 169 empowers any *urban* authority to provide abattoirs or public slaughter-houses, and makes it obligatory to make bye-laws for the management, and charges for the use of the same. For the purpose of enabling any *urban* authority to regulate slaughter-houses within their district the provisions of the Towns Improvement Clauses Act, 1847, with respect to slaughter-houses, are incorporated with the Public Health Act, 1875. These provisions empower *urban* authorities to license slaughter-houses and knackers' yards, and without such license no place shall be used for such purposes which was not so used at the time of the passing of the 1875 Act. Every place used as a slaughter-house or knackers' yard shall be registered by the owner or occupier in a book kept for that purpose, and if any person is convicted of killing or dressing any cattle contrary to the provisions of the Public Health Act, or of the non-compliance with any bye-laws or regulations, the justice before whom he is convicted may suspend the license for two months, and on a second conviction may revoke the license. (A similar revocation of license may follow on conviction of sale of meat unfit for food under Section 30 Public Health Acts (Amendment) Act, 1890.) Further, the above provisions render it obligatory on every *urban* authority to make bye-laws in respect to slaughter-houses and knackers' yards within their districts.

Section 170 provides that a legible notice bearing the words "Licensed Slaughter-House" or "Registered Slaughter-House" must

be attached and displayed in some conspicuous place on every slaughter-house by the owner or occupier.

It will be seen from the above that the distinction between a registered and a licensed slaughter-house depends upon the fact that the former was used as such before the passing of the Act, and the latter has been established after that date. Rural authorities can obtain the necessary *urban* powers for regulating slaughter-houses by application to the Local Government Board (see *ante*, p. 608), or by adopting Part III. of the Public Health Acts (Amendment) Act, 1890. In any district, whether urban or rural, in which this Act has been adopted, licenses granted before its adoption are permanent licenses, nor is a fresh license necessary when part of the premises are rebuilt or any addition is made to them, but discontinuance of use as a slaughter-house will necessitate a fresh license before the premises can be again occupied as such. Where Part III. of the 1890 Act is in force, licenses granted after the date of its adoption will be for not less than twelve months, or for such periods as the sanitary authority may deem fit to specify in the license.

Although urban sanitary authorities can refuse to license new slaughter-houses, they have no power, except under private Acts, to close existing slaughter-houses even when they have provided public abattoirs, and then, of course, only on compensation. But slaughter-houses in the crowded parts of towns are always more or less of nuisance, no matter how well the regulations may be carried out, and it is highly desirable that an adoptive Act should be passed giving urban authorities powers to close and compensate without having recourse to the cumbrous and expensive procedure of applying for private Acts.

In respect to new slaughter-houses, or premises for which a license is sought, the Local Government Board issued in 1877 the following memorandum for the guidance of sanitary authorities:—

In framing a model series of bye-laws the Board have considered that the statutory terms do not warrant the extension of the scope of the bye-laws to regulations directly affecting the structure of the

premises. But in the discretionary power of licensing which has been conferred upon the sanitary authority the following rules as to site and structure should influence their decision upon each application for a license :—

(1) The premises . . . should not be within 100 feet of any dwelling-house ; and the site should be such as to admit of free ventilation by direct communication with the external air on two sides at least of the slaughter-house.

(2) Lairs for cattle in connection with the slaughter-house should not be within 100 feet of a dwelling-house.

(3) The slaughter-house should not in any part be below the surface of the ground.

(4) The approach to the slaughter-house should not be on an incline of more than one in four, and should not be through any dwelling-house or shop.

(5) No room or loft should be constructed over the slaughter-house.

(6) The slaughter-house should be provided with an adequate tank or other proper receptacle for water, so placed that the bottom shall not be less than six feet above the level of the floor of the slaughter-house.

(7) The slaughter-house shall be provided with means of thorough ventilation.

(8) The slaughter-house should be well paved with asphalte or concrete, and laid with proper slope and channel towards a gulley, which should be properly trapped and covered with a grating, the bars of which should not be more than three-eighths of an inch apart. Provision for the effectual drainage of the slaughter-house should also be made.

(9) The surface of the walls in the interior of the slaughter-house should be covered with hard, smooth, impervious material to a sufficient height.

(10) No water-closet, privy, or cess-pool should be constructed within the slaughter-house. There should be no communication between the slaughter-house and any stable, water-closet, privy, or cess-pool.

(11) Every lair for cattle in connection with the slaughter-house should be properly paved, drained, and ventilated. No habitable room should be constructed over any lair.

It is the duty of the sanitary authority to make bye-laws for the regulation of slaughter-houses, and the following is a summary of model bye-laws issued by the Local Government Board :—

(1) *Licenses.*—Applications for license of existing premises, or erection of new slaughter-houses, must be made upon a specified form, and must include full particulars as to boundaries, area, and site ; the position, form, area, cubic space, etc., of the buildings and appendages ; materials and construction of walls ; extent of paved area and paving materials ; means of water-supply, drainage, lighting, and ventilation ; means of access for cattle ; number, position, and size of stalls or lairs, and number of animals to be accommodated therein, distinguishing oxen, calves, sheep, and swine. In the case of old premises, particulars as to the ownership and the applicant's tenure must be given.

(2) *Registration.*—If the sanitary authority approve the application, a license on a prescribed form shall be issued to the applicant, and must be registered by him at the office of the sanitary authority.

(3) *Inspection.*—Free access to every slaughter-house for the purpose of inspection must be afforded at all reasonable times to the medical officer of health, inspector, surveyor, and committees appointed by the sanitary authority.

(4) *Water.*—Wholesome water must be supplied to every animal kept in a pen or lair prior to slaughter in sufficient quantity.

(5) *Mode of Slaughter.*—Cattle must be secured by the head so as to be felled with as little pain as practicable.

(6) *Drainage, water-supply, and ventilation* must be kept in proper order and efficient action.

(7) *Cleanliness.*—The walls and floor must be kept in good order and repair, and must be thoroughly cleansed within three hours after any slaughtering. The walls and ceiling must be lime-washed four times yearly, that is to say, within the first ten days of March, June, September, and December respectively.

(8) *Animals not to be kept.*—No dog may be kept in a slaughter-house: nor other animal, unless intended for slaughter upon the premises, and then only in proper lairs, and not longer than may be necessary for preparing it for slaughter by fasting or otherwise.

(9) *Removal of Refuse.*—Suitable vessels made of non-absorbent materials, and provided with close-fitting covers, must be provided for the reception of blood, manure, garbage, and other refuse; all such matters must be placed in these vessels immediately after the slaughtering, and the vessels must be kept thoroughly clean when not in actual use. The refuse, including all skins, fat, and offal, must be removed within twenty-four hours.

In **London,** the licensing authority is the County Council, and in the city it is the Commissioners of Sewers (Section 20 of the Public Health (London) Act, 1890). The general provisions are similar to those which apply to England and Wales, and Section 47 (5) empowers the court to revoke a license on conviction for selling unsound meat.

In **Scotland,** "the business of a slaughterer of cattle or horses, or knacker," as has already been shown (see *ante*, p. 643), is included in the list of offensive trades, and the provisions relating to licensing are dealt with in Section 33 of the Public Health (Scotland) Act, 1897. Local authorities, other than burghs, are empowered to make bye-laws by Section 32 (3), which would be on lines similar to those already indicated. Section 34 empowers local authorities to provide public slaughter-houses. In burghs, slaughter-houses are under the control of the commissioners who are empowered to license; and if they provide public slaughter-houses, no others may be used (Sections 278-287 Burgh Police (Scotland) Act, 1892).

In **Ireland,** the provisions of the Public Health (Ireland) Act, 1878 (Sections 105 and 106), dealing with slaughter-houses, are similar to those in force in England and Wales. The English bye-laws, with some slight modifications, also apply, with the addition that in Ireland an urban authority

may make bye-laws for the decent conveyance of meat through the public thoroughfares.

If Section 47 of the Towns Improvement (Ireland) Act, 1854, has been adopted, all the provisions will be in force respecting slaughter-houses, though such towns may not be urban districts, and the town commissioners may, by "special order," provide public slaughter-houses.

XIV.—Cellar-Dwellings

Section 71 of the Public Health Act, 1875, enacts that no cellar-dwelling, built or rebuilt since 1848, can be occupied separately as a dwelling, which was not lawfully so let at the time of the passing of the Act, and under Section 72 no existing cellars can be let or occupied unless under the following conditions:—(1) The height of the cellar must be at least 7 feet from floor to ceiling—3 feet of which must be above the surface of the adjoining street or ground. (2) An open area, at least 2½ feet wide in every part, and 6 inches below the level of the floor, must extend along the entire frontage, and though such area may be crossed by steps, these must be 6 inches clear of the wall, and not across or opposite any window. (3) The cellar must be effectually drained by a drain at least 1 foot below the level of the floor. (4) There must be proper closet accommodation. (5) There must be a fireplace and chimney, and a window made to open, of an area at least 9 square feet clear of the window-sash. If, however, there is a back cellar let with the front cellar, the window of such cellar need only be 4 square feet in area. Section 73 imposes a daily penalty not exceeding 20s. on any person letting, or allowing to be occupied, any cellar contrary to the provisions of the Act; Section 74 declares that any cellar is deemed to be occupied as a dwelling if any one passes the night in it; while Section 75 gives power to close cellars on two convictions within three months.

In **London**, the provisions as to cellar-dwellings under Sections 96-98 of the Public Health (London) Act, 1891, are somewhat more stringent, and are as follows:—

No underground room not let or occupied before 1st January 1892 can be so let or occupied unless:—(*a*) every part is 7 feet high, and the ceiling is at least 3 feet above the surface of the adjoining street; but, if the area outside is as much as 6 feet in width, or not less wide than the depth of the floor below the ground-level, then the height may be 1 foot above the street; (*b*) every wall has a damp-course, and, if in contact with the soil, is effectually secured from

damp from the soil; (*c*) there is an open area outside along the frontage, 4 feet wide in every part, and 6 inches below the floor-level, which may be crossed by steps but not opposite a window; (*d*) the area and the soil immediately below the room are effectually drained; (*e*) the hollow space (if any) below the floor is ventilated to the outer air; (*f*) any drain passing under the room is properly constructed of gas-tight pipe; (*g*) the room is effectually secured against the rising of any effluvia or exhalation; (*h*) there is a proper water-closet and ash-pit in a convenient place; (*i*) there is effectual ventilation; (*j*) there is a fireplace, with chimney; (*k*) there are one or more windows opening directly into the open air, the window area being at least one-tenth of the floor area, and so constructed that at least half of each window can be opened, and in each case opening to the top.

Section 96 (2) also imposes a daily penalty for default not exceeding 20s., while (3) applies the foregoing provisions to underground rooms let or occupied separately as dwellings before the passing of the Act; but the sanitary authority may, by general regulations, or on application of the owner, modify any conditions newly imposed by the Act which involves structural regulations. Section 97 gives power of entry and inspection, while Section 98 confers power of closure on two convictions within three months as in the 1875 Act.

In **Scotland,** the provisions in respect to cellar-dwellings, under Sections 74-76 of the Public Health (Scotland) Act, 1897, are in some respects even more stringent than those applying to London. For example, every cellar-dwelling or room, occupied before the passing of the Act, must be not less than 8 feet in height, and not less than 9 feet in the case of houses built subsequently to the Act. The conditions as to warming, ventilation, drainage, etc., are similar, but the window space must be not less than 9 square feet clear of the ground. The local authority is bound to issue notice of prohibition of occupation on any one who lets separately, or knowingly permits to be occupied, any such dwelling contrary to the provisions of the Act, and the person so offending is liable to a daily penalty of not less than 20s. (Section 75). Section 76 gives power to close on two convictions within three months.

In **Ireland,** the provisions as to cellar-dwellings under Sections 82-86 of the Public Health (Ireland) Act, 1878, are practically identical with those contained in the English Act of 1875.

XV.—Common Lodging-Houses

Although there is no definition of a common lodging-house in the Public Health Acts, it is generally understood to be "that class of house in which persons of the poorer class are received and, though strangers to one another, are allowed to inhabit one common room." Sections 76-89 of the Public Health Act, 1875, contain the provisions applying to common lodging-houses, and these may be summarised as follows:—

Every rural and urban authority is required to keep a register of all common lodging-houses in their district, and to see that all such houses and the keepers thereof are registered. They shall not register any house as a common lodging-house until it has been inspected and approved; they may refuse to register any lodging-house keeper unless he produces a satisfactory certificate of character; and they may require every registered keeper to affix the words, "registered common lodging-house," in some conspicuous place on the outside of such house. Every local authority *shall* also from time to time make bye-laws—(1) for fixing the number of lodgers, and for the separation of the sexes; (2) for promoting cleanliness and ventilation; (3) for notifying cases of infectious disease and taking proper precautions; and (4) generally for the well-ordering of such houses.

When a lodging-house is without a proper water-supply the local authority may enforce such supply if it can be provided at a reasonable cost. Further, the keeper of a lodging-house is required to lime-wash the walls and ceilings twice a year (in the first week of April and October); to make a return of beggars or vagrants received into the house to the local authority, when requested to do so, in writing; to give immediate notice to the medical officer of health and the relieving officer of any case of fever or infectious disease; and to give free access at all times to any officer of the authority to any part of the house. Any person who refuses such access will be liable to a penalty not exceeding £5, and in districts, whether urban or rural, in which Part III. of the Public Health Acts (Amendment) Act, 1890, has been adopted, a daily penalty not exceeding 5s. is imposed on any lodging-house keeper who fails to give notice to the medical officer of health or relieving officer of any case of infectious disease.

In a memorandum issued by the Local Government Board it is enjoined that no house should be approved for registration as a lodging-house unless—

The sanitary conditions are in every respect satisfactory, and

the accommodation and arrangements are suitable for the purpose of receiving a number of lodgers. The foundations should be dry, and the yards well paved. The inside walls should not be papered. Every room should have adequate ventilation, and no rooms partially underground should be used as sleeping rooms. In addition to the sleeping rooms there should be at least one common sitting room, exclusive of the kitchen. The closet accommodation for each sex should be one closet for every twenty registered lodgers. The washing accommodation, wherever practicable, should be in a special place, and not in the bedrooms; the basins for personal washing being fixed, and the waste pipes properly trapped and disconnected.

The following is a summary of the Model Bye-Laws issued by the Local Government Board:—

(*a*) Notice stating the *maximum number* allowed in each room should be affixed to the doors or exhibited in the rooms—the number to be based on an allowance of 300 cubic feet for each adult, and 150 cubic feet for each child under ten. (*b*) *Separation of the sexes.*—No child above ten should sleep in the same room with persons of the opposite sex, and no bed should be occupied by more than one male above ten years. Rooms should be set aside for the sole use of married couples, provided that every bed is screened off. (*c*) *Cleanliness of premises.*—All floors should be swept daily, and washed once a week; and all windows, painted surfaces, and fittings kept clean. Yards, etc., must be kept clean and in good order. (*d*) *Closets and ash-pits.*—These must be kept clean and in good order. (*e*) *Sleeping-rooms.*—Windows must be opened for an hour every morning and afternoon, except on account of stress of weather, or when the room is occupied by a sick person. Beds must be well aired for an hour each day, by stripping off the bedclothes, and must not be reoccupied within an interval of eight hours after being vacated. Every sleeping-room must be provided with sufficient bedsteads, beds, bedding, and utensils for the maximum number of lodgers allowed in the room. All slops and refuse must be removed every day before 10 A.M., and all utensils cleaned daily. (*f*) *Washing.*—A sufficient supply of basins, water, and towels must be provided and kept clean for the use of the lodgers. (*g*) *Precautions against infectious disease.*—Besides giving immediate notice of any cases of infectious disease, the keeper must at once take all necessary precautions. No person except a relative or attendant must occupy the same room; and as regards removal of patients to hospital, disinfection, etc., he must obey the instructions of the medical officer of health. He must not receive any lodger into a room in which there has been an infectious case until two days after cleansing and disinfection have been completed. (*h*) *A copy of the bye-laws* must be placed in some conspicuous part of the house, and must not be concealed or altered.

In **London**, the powers and duties of the Police Commissioners under the Common Lodging-Houses Acts of 1851 and 1853 were in 1894 transferred, by order of the Local Government Board, and confirmed by Act of Parliament, to the London County Council. They are practically identical with those which apply to the country generally. In the

city, however, the provisions as to common lodging-houses are under the control of the Commissioners of Sewers.

In **Scotland,** the provisions of the Public Health (Scotland) Act, 1897 (Sections 89-100), are similar to those in force in England, and are under the control of the local authorities. A common lodging-house, however, is defined (Section 3) as "a house or part thereof where lodgers are housed at an amount not exceeding fourpence per night for each person," but with the approval of the Local Government Board the amount may be diminished or raised, but not to exceed sixpence.

In **Ireland,** the provisions of the Public Health (Ireland) Act, 1878, relating to common lodging-houses, conform very closely to those which apply to England, but the provision empowering a sanitary authority to remove a lodging-house from the register until a proper water-supply is provided is made compulsory (Section 93). A common lodging-house is defined by Section 2 as "a house in which, or in any part of which, persons are harboured or lodged for hire for a single night, or for less than a week at a time." The Model Bye-Laws issued by the Local Government Board for England will apply, with some slight modifications, to Ireland.

XVI.—Tenement Houses and Houses let in Lodgings

Under Section 90 of the Public Health Act, 1875, and the unrepealed Section 8 of the Housing of the Working Classes Act, 1885, every sanitary authority is empowered to make bye-laws for houses let in lodgings, but the Local Government Board have advised that such bye-laws are unnecessary for tenement houses of the better class when it may be reasonably inferred that they would be well-managed by the occupiers themselves. The Model Bye-Laws issued by the Board with respect to such houses are on similar lines to those summarised for common lodging-houses, but as there is no legal obligation imposed with respect to registration, the bye-laws enjoin that the landlord or his agent should furnish a statement when required by

the sanitary authority of (1) the total number of rooms in the house; (2) the number let in lodgings or occupied by members of more than one family; (3) the use of each room; (4) the number, age, and sex of the occupants of each room; (5) name of lessee of each room; and (6) rent charged. The Model Bye-Laws, however, do not deal with the separation of the sexes, but they lay it down that if a room is not used exclusively as a sleeping-room, the cubic space should be at least 400 feet for each adult and 200 for each child under ten years of age.

Under Section 214 of the Merchant Shipping Act, 1894, the sanitary authorities of seaport towns are empowered to make bye-laws with respect to Seamen's Lodging-Houses subject to the approval of the President of the Board of Trade. Such bye-laws must provide, *inter alia*, for licensing, publication of the license, inspection, general sanitation, and the exclusion of improper persons, and penalties are imposed. Section 259 of the same Act empowered councils of municipal boroughs, which are ports in the United Kingdom, to appropriate lands belonging to them as sites for sailors' homes, with the consent of the Local Government Board.

In **London,** the regulation of tenement houses and houses let in lodgings are vested, in the city, in the Commissioners; and, in the administrative county, in the vestries and district boards. Under Section 94 of the Public Health (London) Act, 1891, they are empowered to make and enforce bye-laws for the several purposes authorised by Section 90 of the Public Health Act, 1875. In respect to seamen's lodging-houses, the powers and obligations conferred by the Merchants Shipping Act, 1894, devolve upon the County Council in the administrative county area, and in the city they devolve on the Commissioners of Sewers.

In **Scotland** and **Ireland,** the provisions of the Merchants Shipping Act in respect to seamen's lodging-houses apply as in England, but although Section 8 of the Housing of the Working Classes Act, 1885, apply to both Ireland and

Scotland, it is doubtful whether its provisions could be enforced by the Local Government Board of either country.

It should here be added that under Section 26 (2) of the Customs and Revenue Act, 1890, it is made incumbent on the medical officer of health to inspect, on request, any houses wholly let in tenements at rents not exceeding 7s. 6d. weekly, and if satisfied that the accommodation and sanitary requirements are in every respect satisfactory, his certificate, or that of a medical practitioner appointed for that purpose by the sanitary authority, will exempt from inhabited house duty. The Local Government Board have intimated that they will authorise fees for such certificates.

XVII.—Movable and Temporary Dwellings

For the sanitary control and supervision of the wandering population who live in vans, tents, or sheds, sanitary authorities are vested with certain powers under the Public Health Act, 1875, the unrepealed Sections 9 and 10 of the Working Classes Act, 1885, and the Fruit Pickers Lodgings Act, 1882.

Section 9 of the Working Classes Act, 1885, enacts that a tent, van, or similar structure, used for human habitation, which is in such a state as to be a nuisance or injurious to health, or which is so overcrowded as to be injurious to the inmates, whether or not members of the same family, shall be deemed to be a nuisance within the meaning of Section 91 of the Public Health Act, 1875 (see *ante*, p. 630), and the provisions of that Act shall apply accordingly. A local authority is empowered to make bye-laws in regard to tents, vans, and similar structures, and the section further authorises powers of entry between 6 A.M. and 9 P.M., to any person duly authorised by the local authority, or by a justice of the peace, if such officer has reasonable cause to suspect that there is any contravention of the Act, or of any bye-laws made under it, or that there is in such habitation any person suffering from any dangerous infectious disease, and any one obstructing such officer in the discharge of his duty is liable

to a fine not exceeding 40s. This section applies to the metropolis, but not to any tent, van, etc., used by Her Majesty's naval or military forces. Under Section 10 the provisions of the Public Health Act, 1875, relating to bye-laws made by a sanitary authority shall apply to bye-laws authorised by this Act, and a fine or penalty under any such bye-law may be recovered on summary conviction.

In respect to the lodging of fruit- and hop-pickers, Section 314 of the Public Health Act, 1875, empowers every sanitary authority to make bye-laws for the decent accommodation and lodging of hop-pickers, and these powers have been extended by the Fruit Pickers Lodgings Act, 1882, to enable them to make bye-laws for the proper accommodation and lodging of persons engaged in the picking of fruit and vegetables.

The following is a summary of the Model Bye-Laws issued by the Local Government Board for the regulation of these temporary habitations :—

(1) The habitations must be clean, dry, weather-proof, and properly lighted and ventilated. (2) At least 16 square feet of floor space must be allowed in them for each adult and for every two children under ten years of age. (3) When intended for the reception of adults of different sexes, the habitations must be so furnished that every bed is properly separated from any adjoining bed by a suitable screen or partition. (4) There must be a separate cooking-place for every fifteen persons authorised to be received ; (5) A sufficient supply of good water for drinking, cooking, and washing ; and (6) adequate privy accommodation for the separate use of each sex. (7) Every lodger or occupant shall be provided with a sufficient supply of clean dry straw, or other clean, dry, and suitable bedding, which must be changed or properly cleansed from time to time, as occasion may require. (8) Every part of the interior of the premises, the cook-houses and privies must be thoroughly cleansed immediately before any person is received to lodge therein, the internal surfaces lime-washed, and all offensive accumulations cleared away. The cleansing and lime-washing must be done at least annually, and repeated as required from time to time during the period of occupation.

In **London,** Section 9 of the Working Classes Housing Act, 1885, applies, while Section 95 of the Public Health (London) Act, 1891, also vested sanitary authorities throughout the metropolis with all the powers of control and regulation of bye-laws provided, as already described, under Sections 9 and 10 of the 1885 Act.

In **Scotland,** the provisions as to tents and vans are given in Section 73 of the Public Health (Scotland) Act,

1897, and are practically identical with those contained in Sections 9 and 10 of the Working Classes Act, 1885, but as Section 15 of the Act, which applied to **Ireland** the provisions contained in Sections 9 and 10, has been repealed, it is doubtful whether these sections can be put in force in that country.

XVIII.—Canal Boats

As large numbers of the working population live in canal boats, their health interests are protected by special legislation, and there can be no question that the operation of the Canal Boats Acts of 1877 and of 1884 has been attended with very satisfactory results. These Acts, however, only apply to England and Wales, including the metropolitan area, and they entrust the supervision of canal boats to every sanitary authority through whose district a canal passes, or any piece of water coming under the definition of canal. So far as their districts are not within the jurisdiction of the Port Sanitary Authority of London, the vestries and district boards are the sanitary authorities for the purposes of the Acts in the metropolis.

The Canal Boats Act 1877.—By Section 14 of the Act, the expression "canal" includes any river, inland navigation, lake, or water within the body of a county whether it is or is not within the ebb or flow of the tide. "Canal boat" means any vessel, however propelled, which is used for the conveyance of goods along a canal, and which is not a ship duly registered under the Merchant Shipping Act.

Section 1 provides that no canal boat shall be occupied as a dwelling unless it be registered, and it can only be used by the number of persons of the age and sex for which it is registered, under a penalty. Under Section 2, the Local Government Board shall make regulations, which they may revoke or alter from time to time—(1) for registration; (2) for marking, lettering, or numbering; (3) for fixing the number, age, and sex of persons who may be allowed to use a boat; (4) for promoting cleanliness; and (5) for the prevention of disease. Section 3 provides that upon registration two certificates shall be given to the owner, one of which must be carried by the master, identifying the owner and the boat, and stating the place to which the boat belongs, and the number, age, and sex of the persons allowed to dwell in it. Every registered boat must have conspicuously painted or affixed upon it the word "registered," the name of the place to which it be-

longs, and the registered number. Section 4 empowers sanitary authorities, on receiving information of the existence of a case of infectious disease on board a boat, to exercise all the powers vested in them by the Public Health Act, 1875, for the prevention of the spread of disease in dwellings, removal of the patients if practicable and necessary, and disinfection; and for all these purposes the boat may be detained until after it has been disinfected. Section 5 gives power of entry to the officer of the sanitary authority between the hours of 6 A.M. and 9 P.M., if he has reason to suspect any contravention of the Act, or that any one on board is suffering from infectious disease, or for purposes of inspection. The master of the boat is bound to produce his certificate (if any) and to afford facilities to the officer for entry and departure from the boat. A refusal to comply with the requisition of the officer shall be deemed to be an obstruction, and renders the person so obstructing liable to a penalty. Section 6 provides for the education of children on board canal boats; while Section 7 enacts that the registration authority must be a sanitary authority whose district abuts on the canal on which such boat is intended or accustomed to ply, or one or more of such authorities as the Local Government Board may from time to time prescribe by regulation. The boat must also be registered as belonging to some place in the said district, and which is also either a school district or part of a school district.

The regulations, which the Local Government Board, directed by Section 2, issued in 1878, are briefly as follows:—There must be at least one cabin, which must be kept dry, clean, weather-proof, and in good repair. An after cabin to be used as a dwelling must contain not less than 180 cubic feet, and a fore-cabin 80 cubic feet of free air space. Every such cabin must be ventilated independently of the door, and must afford adequate sleeping accommodation. One cabin must contain a stove and chimney, and the boat must be furnished with suitable storage for at least three gallons of drinking water. If the boat is intended to carry offensive cargoes, the hold must be separated from any inhabited cabin by a double bulkhead, with an interspace of 4 inches, and the bulkhead next the cargo must be water-tight. For each person over twelve years of age, not less than 60 cubic feet of free air-space shall be allowed, and not less than 40 feet for each child under that age. In fly-boats worked by shifts, a cabin occupied by two persons at the same time must have at least 180 cubic feet free air-space. No male over fourteen years of age, or female over twelve, must sleep in the same cabin with a married couple, nor must a male over fourteen or a female over twelve occupy the same sleeping-cabin at the same time. Exceptions, however, are made in respect to married couples, and there are also reservations in respect to boats built prior to the passing of the Act. The interior of any cabin must be kept clean and painted every three years, and bilge water must be pumped out daily. The master of the boat is bound to notify forthwith any case of infectious disease occurring in the boat to

the sanitary authority of the district through which the boat may be passing at the time, and also to the sanitary authority of the place of destination. He must also inform the owner, who is required to notify to the sanitary authority of the place to which the boat belongs. If the sanitary authority deems it necessary to detain the boat for purposes of disinfection, they must furnish a medical certificate to the master that the boat has been cleansed and disinfected, and the master cannot proceed until such certificate has been obtained. The sanitary authority may pay a reasonable sum for any such certificate.

The *Canal Boats Act* of 1884 amends the Act of 1877—

Section 1 nullifies any certificate of registration when any structural alterations are carried out which affect the conditions under which the certificate was granted; Section 2 imposes a penalty for contravention of regulations; and Section 3 makes it incumbent upon every authority through whose district any canal or canals pass to enforce the provisions of the Act and the above regulations, and to make a report to the Local Government Board within twenty-one days after the close of each year, on the steps taken to give effect to the Act and regulations. Under Section 4 the Local Government Board is required to present a report annually to both Houses of Parliament as to the execution of both Acts and observance of regulations, and to cause inquiries to be made from time to time by an inspector or inspectors appointed for that purpose, who have similar powers to poor law inspectors as to the production of papers, examination of witnesses, etc., and have full powers of entry on all boats. Sections 5 and 6 refer to the education of children on canal boats, and Section 7 enjoins that every boat shall be conspicuously lettered, marked, or numbered, either on both sides of the boat, or on the stern.

XIX.—Housing of the Working Classes

The numerous Acts which have been passed from time to time for dealing with unhealthy dwellings have been for the most part repealed, and have been codified and extended by the Housing of the Working Classes Acts of 1885 and 1890. With the exception of Section 3 of the 1885 Act, which empowered the Treasury to sell the sites of certain metropolitan prisons when no longer required, and Sections 7, 8, 9, and part of 10, the whole of this Act is also repealed by the 1890 Act. Sections 8, 9, and 10 have already been summarised in respect to tenement houses and movable dwellings, and Section 7 only emphasises the duty

which is laid on every sanitary authority to put in force the powers with which they are invested to secure the proper sanitary condition of all premises within their district.

With the above exceptions, the Housing of the Working Classes Act, 1890, repeals the whole of the previous Acts relating to labourers' lodging-houses and dwellings, and artisans' dwellings, and is made applicable to England and Wales, London, Scotland, and Ireland. Part I., which supersedes Cross's Acts, deals principally with unhealthy areas, and does not apply to rural districts. Part II., which replaces Torrens's Acts, applies to rural and urban districts, and relates chiefly to unhealthy or obstructive dwellings. Part III., which consolidates the Shaftesbury Acts, applies to all sanitary authorities, and authorises them to provide lodging-houses for the working classes, subject to the approval of the Local Government Board, as regards urban authorities, and the County Council as regards rural districts. In the county of London, the administration of this part of the Act is vested in the County Council; while in the city the administration of all three parts is vested in the Commissioners.

Part I.—Unhealthy Areas

Section 4 enacts that when an official representation is made to the local authority, that within a certain area in their district, (*a*) any houses, courts, or alleys are unfit for human habitation; or (*b*) that the narrowness, closeness, and bad arrangement, or the bad condition of the streets and houses, or groups of houses within such area, or the want of light, air, ventilation, or proper conveniences, or any other sanitary defects, or one or more of such causes, are dangerous or injurious to the health of the inhabitants, either of the buildings in the said area, or of the neighbouring buildings; and that the evils connected with such houses, courts, or alleys, and the sanitary defects in such area, cannot be effectually remedied otherwise than by an improvement scheme for the rearrangement and reconstruction of the streets and houses within such area, or of some of such streets or houses, the local authority shall take such representation into their consideration, and if satisfied of the truth thereof, and of the sufficiency of their resources, shall pass a resolution to the effect that such area is an unhealthy area, and that an improvement scheme ought to be made in respect of such area, and after passing such resolution they

shall forthwith proceed to make a scheme for the improvement of such area. Provided always that any number of such areas may be included in one improvement scheme.

Section 5 provides that such official representation shall be made by the medical officer of health, whenever he sees cause to make the same, or if two or more justices, or twelve or more ratepayers, make complaint to him of the unhealthiness of any area, he is bound to inspect such area, and report to the local authority. Under Section 6 an improvement scheme may (*a*) exclude any part of the area, or include any neighbouring lands, for making it efficient for sanitary purposes ; (*b*) may provide for widening any existing approaches for purposes of ventilation or health ; (*c*) shall provide such dwelling accommodation, if any, for the working classes, displaced by the scheme, as is required to comply with the Act ; and (*d*) shall provide for proper sanitary arrangement.

After due publicity has been given to the scheme, by advertising and serving notices, in a manner specified by Section 7, the local authority is required by Section 8 to present a petition to the Secretary of State, if it relates to any part of London, and to the Local Government Board, if it relates to any other urban district, praying that an order may be made to confirm the scheme. The confirming authority shall then direct a local inquiry to be held concerning the sufficiency or otherwise of the scheme, and upon receiving the report, may make a provisional order, which must be confirmed by Act of Parliament as a confirming Act. Such provisional order may approve or modify the scheme, so that no addition be made to the lands proposed to be taken compulsorily. Section 10 requires a local authority, where any official representation is made, to take such representation into consideration, and if they fail to pass any resolution in relation to it, or pass a resolution to the effect that they will not proceed with such scheme, they must send a copy of the official representation, with their reasons for not acting upon it, to the confirming authority, who may direct a local inquiry to be held.

As regards provision of dwelling accommodation for the working classes displaced by the scheme, Section 11 enacts that, in London, accommodation must be provided in or near the area for the whole number displaced, unless the order decrees otherwise, by accepting in substitution equally convenient accommodation outside the area, and dispensing with the obligation to provide accommodation to any extent not exceeding one-half. In other parts of the country such provision is only compulsory if and to the extent required by the confirming authority after local inquiry. After a confirming Act has been passed, provisions are set forth in several sections for the execution of the scheme, and for the acquisition of land. In assessing the value of property, Section 21 provides that no additional allowance for compulsory purchase is to be made in regard to any unhealthy portion of the area, and the arbitrator may receive evidence, showing

that any premises are (1) rented too highly by reason of overcrowding or being used for illegal purposes; (2) that the premises are in such a condition as to be a nuisance or injurious to health; or (3) that the premises are unfit, and cannot reasonably be made fit, for human habitation. In the first case, the compensation is to be based on the rental which would have been obtainable, if the house or premises had not been overcrowded or used for illegal purposes; in the second case, on the amount estimated as the value of the premises, assuming that they had been habitable, after deducting the estimated expense of abating the nuisance or putting them in habitable repair; and in the third case, on the value of the land and the materials of the buildings only.

Section 16 provides that where complaint is made, by twelve or more ratepayers, to the medical officer of health of the unhealthiness of any area in their district, and he fails to inspect such area or to make an official representation thereon, or has made an official representation to the effect that, in his opinion, the area is not an unhealthy area, such ratepayers may appeal to the confirming authority, who may then appoint a medical practitioner to inspect such area and report to them. This report shall be transmitted to the local authority, and if it states that the area is an unhealthy area, the local authority shall proceed in the same manner as if it were an official representation made to them, and either prepare a scheme, or report the facts to the confirming authority, who may then order a local inquiry to be made. Section 26 provides that, in the case of the illness or unavoidable absence of the medical officer of health, the authority or vestry who appointed him may, subject to the approval of the confirming authority, appoint a duly qualified medical practitioner, for the period of six months, or any less period, to act as medical officer of health.

Part II.—Unhealthy Dwelling-Houses

Section 30 requires the medical officer of health of every district to represent to the local authority any dwelling-house which appears to him to be unfit for human habitation; while Section 31 makes it incumbent on him, when any four householders complain that a house near which they live is unfit for human habitation, to forthwith inspect the same, and transmit to the authority the said complaint, together with his opinion thereon; but the absence of any such complaint shall not excuse him from inspecting any dwelling-house and making a representation thereon to the authority. If within three months after receiving the said complaint and opinion or representation of the medical officer, the local authority, not being a rural authority or in the county of London, declines or neglects to take proceedings, the householders who signed the complaint may petition the Local Government Board, and, after inquiry, the Board may order the authority to proceed under this part of the Act, and such order shall be binding.

Closing Order and Demolition.—Section 32 provides that proceedings may be taken for closing a dwelling-house whether it be occupied or not.

With regard to the precise mode of proceedings which the provisions of this part of the Act impose on local and confirming authorities, the following extracts from the circular issued by the Local Government may here be fitly quoted as applying to England and Wales:—

"Section 32 expressly declares that it shall be the duty of every sanitary authority to cause to be made from time to time systematic inspection of their district with a view to ascertain whether any dwelling-house therein is in a state so dangerous or injurious to health as to be unfit for human habitation, and if, on the representation of their medical officer of health or any of their officers, or information given to them, any dwelling-house appears to be in such state, to forthwith take proceedings against the owner or occupier for closing it under Sections 91, 94, 95, and 97 of the Public Health Act, 1875 (see *ante*, pp. 630-644).

"In connection with this section and with the provisions relating to obstructive buildings which are contained in this part of the Act, and to which reference is hereinafter made, it should be stated that Section 52 provides that a representation from the medical officer of health of any county, submitted to the County Council, and forwarded by that Council to the local authority of any district in the county, not being a borough as defined by the Municipal Corporations Act, 1882, shall, for the purpose of this part of the Act, have the like effect as a representation from the medical officer of health of the district.

"Under the Sections of the Public Health Act above referred to, it has hitherto been necessary that the proceedings should be taken with a view to the abatement of a nuisance, and that the works requisite to abate the nuisance complained of should be specified. This, however, will no longer be the case. Section 32 (2) authorises summary proceedings to be taken for the express purpose of causing the dwelling-house to be closed, and appropriate forms are contained in the Fourth Schedule to the Act, which may be used for this purpose.

"The closing order will prohibit the using of the premises for the purpose of human habitation until, in the judgment of the court, they are rendered fit for that purpose. In making it, the court may impose a penalty not exceeding twenty pounds, and may authorise a reasonable allowance to be paid by the sanitary authority to every occupying tenant on account of his expenses in removing from the dwelling-house. The amount of this allowance will be a civil debt due from the owner of the dwelling-house to the sanitary authority, and will be recoverable summarily.

"Where a closing order has been made in respect of any dwelling-house, and has not been determined by a subsequent order, the sanitary authority, if of opinion that the house has not been rendered fit for human habitation, and that the necessary steps are not being taken with all diligence to render it so fit, and that the continuance of any building being or being part of the dwelling-house, is dangerous or injurious to the health of the public, or of the inhabitants of the neighbouring dwelling-houses, are required by Section 33 to pass a resolution that it is expedient to order the demolition of the building.

"A notice of this resolution must be served on the owner, specifying the time (not less than one month from the service of the notice) and the place appointed by the sanitary authority for the further consideration of the resolution; and any owner will be at liberty to attend and to state his objection to the demolition.

"If upon the consideration of the resolution and the objections the sanitary authority decide that it is expedient so to do, then unless an owner undertakes to execute forthwith the works necessary to render the dwelling-house fit for human habitation, and executes the same within a limited period, the authority are required by the Act to order the demolition of the building.

"Where such an order has been made, any person aggrieved by it may appeal against it to the next court of quarter sessions, but subject to this appeal, and to the power given by Section 47 of the Act to a court of summary jurisdiction to enlarge the time allowed for the demolition of the building, the owner must, within three months after service of the order, proceed to take down and remove the building, and on his default the sanitary authority are required themselves to proceed to do this, and to sell the materials, and after deducting the expenses incident to the taking down and removal of the building, to pay over the balance of money, if any, to the owner.

"Where a building has been taken down and removed under the above provisions, no house or other building or erection may be erected on all or any part of the site of the building which is dangerous or injurious to health. Full power is given to the sanitary authority to enforce compliance with the requirement."

Obstructive Buildings.—Under Section 38, if a medical officer of health finds that any building, though not in itself unfit for human habitation, is so situated that it either—(*a*) stops ventilation or conduces to make other buildings to be unfit for habitation or dangerous or injurious to health; or (*b*) prevents the proper remedying of any nuisance injurious to health or other evils complained of in respect of such other buildings, he must make a representation to the local authority of the particulars relating to such obstructive building, stating that in his opinion it should be pulled down. Any four or more inhabitant householders, or in respect to rural districts, a county medical officer (Section 52) may make a similar representation. In

any case, the local authority must make due inquiry into the facts and as to the cost of acquiring the land and pulling down the building. If they resolve to proceed, they may make an order for the demolition of the obstructive building after giving the owner an opportunity of stating his objections, and subject to appeal to quarter sessions. Where no appeal is made against the order, or is made and either fails or is abandoned, the authority may purchase the site, unless the owner, within one month after notice to purchase, declares that he desires to retain the site, and undertakes either to pull down the building or permits the authority to demolish, in which case he will retain the site and receive compensation. He cannot, however, insist on his entire holding being taken, where part only is proposed to be taken as obstructive, and such part can be severed from the remainder of the house or manufactory without material detriment. The compensation to the owner, and also the amount recoverable from the owners benefited by the demolition, are to be settled by arbitration in cases of dispute. Where the owner desires to retain the site, no house or other building which will be injurious to health or obstructive shall be erected thereon; or, if purchased by the authority, the obstructive building must be pulled down and the ground kept as an open space, or dedicated as a highway or other public space.

Schemes for Reconstruction.—Section 39 empowers the local authority to prepare such schemes in any of the following cases—(*a*) where an order has been made for demolition, and it appears to the local authority that it would be beneficial to the inhabitants of the neighbouring houses if the site were used as a highway or open space, or appropriated, sold, or let for the erection of dwelling-houses for the working classes, or exchanged for other neighbouring land more suitable for that purpose; or (*b*) where the closeness, narrowness, and bad arrangement or bad condition of any buildings, or the want of light, air, ventilation, or proper conveniences, or any other sanitary defect in such buildings is prejudicial to the health of the inhabitants of those or neighbouring buildings, and that their demolition is necessary to remove these evils. When a scheme has been prepared in any of the above cases, notice must be given to the owners and occupiers of the improvement area and a petition forwarded to the Local Government Board, who, after a local inquiry, may make an order sanctioning the scheme with or without modifications. When this order has been made, the authority may purchase by agreement. Where no such agreement can be made, notice of the order must be published in the *London Gazette* and served on the owners; and it is only in cases where a petition is presented and not withdrawn that the order will require confirmation by Parliament. The order may require provision to be made for the accommodation of the working classes displaced (Section 40).

In respect to compensation, Section 41 provides that the arbitrator shall base his estimate on the same lines as those already set forth in Section 21, Part I.

When an official representation or complaint has been made under Part II., or a closing order has been made, Section 45 requires a rural sanitary authority to forward forthwith a copy of such representation, complaint, or closing order to the County Council, and report from time to time all further proceedings. Such requirement also applies to all vestries and local district boards in the county of London. If the County Council are of opinion that a vestry, district board, or rural sanitary authority have failed to perform their duties in relation to the closing or demolition of any such dwelling-house, or the pulling down of any such obstructive building, they may themselves take the necessary proceedings for this purpose; and in the event of proceedings being successful and not being disallowed on appeal, they are empowered to recover the expenses incurred by them from the local authority. These powers, however, will not be exercisable until reasonable notice—not being less than one month—has been given in writing to the authority. The County Council and their officers, for the purposes of this section, have the same right of entry on premises as any local authority or their officers, and a justice may make an order for enforcing such admission. Section 52 further provides that a representation from the medical officer of health of any county, submitted to the County Council and forwarded to the local authority, not being a borough as defined by the Municipal Corporations Act, 1882, shall, for the purposes of this Act, have the like effect as a representation from the medical officer of health for the district.

Part III.

This part of the Act, which applies to labouring class lodging-houses, may be adopted by local authorities, provided that in the case of *urban* authorities the sanction of the Local Government Board is obtained; and in respect to *rural* authorities, the sanction of the County Council, after local inquiry. It enables local authorities to purchase or rent land for the erection of lodging-houses, and in *rural* districts this expression includes separate houses or cottages, whether containing one or several tenements. *Rural* authorities are also empowered, with the sanction of the County Council, to provide lodging-houses on land so purchased or rented, or appropriated if vested in them, and to convert any buildings into lodging-houses, and to alter, enlarge, repair, and improve the buildings, and to fit up, furnish, and supply them with the requisite furniture, fittings, and conveniences. It further enables *rural* authorities to contract for the purchase or lease of any lodging-houses for the working-classes already or hereafter to be built and provided, and with the consent of the County Council to appropriate the same for the purposes of this part of the Act, and to sell with such consent any land vested in them for these purposes, and to apply the proceeds in or towards the purchase of more suitable lands (Sections 53-60).

The management, regulation, and control of such lodging-houses are vested in the local authority, and for these purposes the authority is empowered to make bye-laws (Sections 61, 62).

In **the County of London,** the administration of Parts I. and III. are vested in the County Council, and Part II. primarily in the district councils. In the event of doubt or dispute the Secretary of State decides under which part of the Act a given area shall be dealt with. The County Council may, however, prepare schemes under Part II. if they think fit, and may apply to the Secretary of State to order a contribution from the district authority. In like manner, if the district authority resolve to proceed they may apply for a contribution from the County Council (Sections 72-93).

In **Scotland,** the approving authority in the case of urban districts is the Local Government Board or the Secretary for Scotland; and as regards the adoption and execution of Part III. a local authority, being a district committee, is substituted for a rural authority, and the Local Government Board for the County Council (Sections 94-97).

In **Ireland,** the Local Government Board, Ireland, becomes the approving authority, and Part III. of the Act may be adopted in any town, although not an urban district, by the commissioners appointed for the time-being for paving, lighting, or cleansing, and carried into execution by them (Sections 98-101). The general adoption of Part III. is not required in Ireland, owing to the provisions of the various Labourers (Ireland) Acts of 1883, 1885, 1886, 1891 and 1892, which facilitate the erection of dwellings for agricultural labourers by rural authorities.

XX.—Streets and Buildings

In urban districts, or rural districts for which urban powers have been obtained, sanitary authorities possess a large amount of control over the construction of new

streets, planning of new streets, and also in respect to the plans and structural details of new houses; as well as the closing or alteration of old or insanitary dwellings.

Section 149 of the Public Health Act, 1875, vests all public streets, in *urban* districts, in the sanitary authority, who shall cause them to be levelled, paved, metalled, channelled, flagged, and repaired or altered, as they may think fit. Section 150 empowers the authority to require the owners of property, abutting on any private street, or part of a street, to level, pave, sewer, light, or make good such street, or part of a street, and in case of default, the authority may themselves do the work, and recover the expenses from the owners, according to the frontage of their respective premises.

(Section 6 (1) of the Private Streets (Works) Act, 1892, enables any urban authority, by adoption of the Act, and any rural authority, if invested with the powers of the Act by the Local Government Board, to sewer, level, pave, etc., or otherwise make good, and light any private street, or part of a street, which is not in a satisfactory condition in these respects, and apportion the expenses between the adjoiners or owners. They may also contribute to such expenses.)

Section 157 of the 1875 Act empowers every *urban* sanitary authority to make bye-laws, with respect to the following :—

(1) Level, width, and construction of *new streets*, and provisions for the sewerage thereof.

(2) Structure of walls, foundations, roofs, and chimneys of *new buildings* for securing stability and the prevention of fires, and for purposes of health.

(3) Sufficiency of the space about buildings to secure a free circulation of air, and with respect to the ventilation of buildings.

(4) The drainage of buildings, water-closets, earth-closets, privies, ash-pits, and cess-pools, and the closing of buildings, or parts of buildings, unfit for human habitation, and prohibition of their use for such habitation.

Section 158 provides that where a notice, plan, or description of any work is required by any bye-law, made by an *urban* authority, the authority shall, within one month, approve or disapprove of the same, and if the work is commenced after written notice of disapproval, or without approval, and is not in conformity with the bye-laws, the authority may cause so much of the work as has been executed to be pulled down or removed, and may recover the expenses incurred in a summary manner.

Section 159 defines the erection of a new building to include the re-erection of any building pulled down to or below the level of the ground-floor, or of any frame-building of which only the frame-work is left down to the ground-floor, or the conversion into a dwelling-house of any building not originally constructed for human habitation,

or the conversion into more than one dwelling-house of a building, originally constructed as one dwelling-house only.

Section 160 incorporates certain provisions of the Towns Improvement Clauses Act, 1847, with respect to the naming of streets and the numbering of the houses, the line of the streets and removing obstructions, etc., and with respect to ruinous or dangerous buildings. These provisions render it incumbent on the surveyor of an *urban* authority, whenever he is satisfied that any building or wall is in a ruinous state so as to be dangerous to passers by, or to the inhabitants of neighbouring houses, to cause a fence to be put up, and to order the owner forthwith to secure or pull down such building, and in default the surveyor may obtain a justice's order to carry out the necessary works, and may recover the expenses. They also empower an *urban* authority to compel the owner of any building, adjoining or near a street, to provide within seven days sufficient eaves, gutters, and rain-pipes.

Under the Public Health Acts (Amendment) Act, 1890, these powers are increased or largely extended as regards the following:—

Section 23 provides (1) that 157 of the 1875 Act shall be extended so as to empower every *urban* authority, by adoption of the Act, to make bye-laws concerning new buildings with respect to the following matters:—(*a*) Sufficient water-supply to flush closets; (*b*) structure of floors, hearths, and staircases; (*c*) height of rooms intended for human habitation; (*d*) paving of yards and open spaces in connection with houses; (*e*) laying out of new streets of secondary means of access, for the removal of house refuse and other matters. (2) Any bye-laws under that section respecting drainage, the flushing of water-closets, or the construction of earth-closets, privies, ash-pits, and cess-pools may be made so as to affect buildings erected before the passing of the Act. (3) The provisions of the said section, as amended by this Act, so far as they relate to bye-laws with respect to the structure of walls and foundation of new buildings for purposes of health, and with respect to the matter mentioned in Sub-sections (3) and (4) of the said section, and with respect to the structure of floors (see *ante*, p. 371), the height of rooms for human habitation, and to the keeping of water-closets supplied with sufficient water for flushing, shall be extended so as to empower *rural* authorities to make bye-laws in respect to the said matters, and to provide for the observance of such bye-laws, and to enforce the same as if such powers were conferred on *rural* authorities by virtue of an order of the Local Government Board made on the day when this part of this Act is adopted; and Section 158 of the Public Health Act, 1875, shall also apply to any such authority and shall be in force in every rural district where this part of this Act is adopted. (4) Every local authority may make bye-laws to prevent

buildings which have been erected in accordance with bye-laws made under the Public Health Acts from being altered in such a way that if at first so constructed they would have contravened the bye-laws.

Rooms over Privies, etc.—Section 24 prohibits, under a penalty, after seven days' notice, the occupation of any portion of a room whether as a living-room, sleeping-room, or workroom which extends immediately over any privy (not being a water-closet or earth-closet), or over any cess-pool, midden, or ash-pit.

Polluted Sites.—Section 25 enacts that no new building may be erected upon ground impregnated with animal or vegetable matter, or upon which such matter has been deposited, unless such matter has been properly removed or has been rendered or become innocuous. Any one wilfully contravening this section is liable to a penalty not exceeding £5, and a daily penalty not exceeding 40s.

Buildings.—Section 33 provides that buildings described in deposited plans otherwise than as dwelling-houses may not be used as such under a penalty, unless any such building has in the rear thereof such open space as is required by the bye-laws, and the part of the building intended to be used as a dwelling has undergone such alterations as are necessary in the opinion of the local authority to render it fit for human habitation.

Other Provisions.—Sections 34-46 provide *inter alia* for boards to be set up during progress of buildings; repair of cellars under streets; sufficient means of ingress to and egress from places of public resort erected after the adoption of this part of the Act, such as churches, chapels, theatres, concert-rooms, and the like; safety of platforms erected on public occasions; bye-laws for whirligigs and shooting-galleries; construction and maintenance of raised platforms or refuges in streets; provision and maintenance of cabmen's shelters; adoption of private streets; planting of trees in roads; and setting apart the use of public parks and pleasure grounds for special purposes for any number of days not exceeding twelve during the year, or four consecutively.

The following is a summary of the Model Bye-Laws which have been issued by the Local Government Board in respect to the powers vested in sanitary authorities by the above provisions of the Public Health Act, 1875, and by the adoption of Part III. of the Public Health Acts (Amendment) Act, 1890. All the more important of them have been fully explained and illustrated in previous chapters, more particularly in Chapters X. and XIII.:—

1. *New Streets.*—Every new street, which is not a private street, must be not less than 42 feet wide, if it exceeds 100 feet in length or is intended for a carriage road; nor less than 24 feet in any case, and one end must be open

the whole width of the street. If intended for a carriage road, the carriage way must be 26 feet wide, and be provided on each side with a footpath 8 feet wide. Provisions are laid down as to construction, kerbing, paving, channelling, etc.

2. *Building Sites.*—No buildings must be erected upon soil polluted with animal or vegetable matter, and sites in low and damp situations, near rivers or in excavations, must be raised artificially. The site must be entirely asphalted over or covered with concrete to a depth of 6 inches (see p. 368).

3. *Walls* of all new buildings must be constructed of good bricks, stone, or other hard and incombustible materials, properly bonded and solidly put together with good mortar, compounded of good lime and clean sharp sand or other suitable material, or with good cement, or with good cement mixed with clean sharp sand. Every wall must have a proper damp course of durable and impervious material beneath the level of the lowest timbers, and at least 6 inches above the ground. If the ground is to be left in contact with a wall above the level of the floor of the lowest storey, that wall must be made double, with a cavity 2½ inches wide extending from the base of the wall to 6 inches above the surface of the adjoining ground; and damp courses must be inserted both at the base of the wall and at the level of the top of the cavity. The minimum thickness of the wall of a new house should be as follows:—Where a wall is not over 25 feet in height, if it does not exceed 35 feet in length, and does not comprise more than two storeys, it shall be 9 inches for its whole height; but if it do comprise more than two storeys, or exceed 35 feet in length, it shall be 13½ inches below the topmost storey, and 9 inches for the rest. Where walls are over 25 feet high, and not exceeding 35 feet in length, they should be 13½ inches thick below the topmost storey, and 9 inches for the rest; but if they be longer than 35 feet, then they must be 18 inches thick for the height of one storey, then 13½ inches thick for the rest of the height below the topmost storey, and 9 inches thick for the rest of its height. Walls over 35 feet high must be 18 inches thick for the first two storeys, and 13½ inches for the rest. If over 50 feet in height, walls should be 22 inches thick for the height of one storey, then 18 inches for the next two storeys, and finally 13½ for the rest of the height. Party walls must be carried up at least 15 inches above the roof, the distance to be measured at right angles to the slope of the roof (see pp. 369-372).

4. *Roofs* must be made of incombustible materials, and provided with gutters or spouts leading to rain-water pipes.

5. *Open Space.*—Every new house must have along its whole frontage an open space measuring at least 24 feet to the boundary of any land or premises immediately opposite, or to the opposite side of the street. In the rear there must be an open space exclusively belonging to the house, at least 150 square feet in area, and free from any erection above the ground-level, except a closet and an ash-pit. Such open space must extend along the entire width of the house, and must measure in no case less than 10 feet from every part of the back wall of the house; if the house is 15 feet high, the distance must be 15 feet; if 25 feet, then 20 feet; and if 35 feet or more, then 25 feet at least.

6. *Ventilation, etc.*—If the floor of the lowest storey is boarded, there must be a clear space of at least 3 inches between the boards and the impervious covering of the site, and the space must be ventilated. Every habitable room must be provided with windows opening directly into the external air. The window area must be at least one-tenth of the floor area; at least half of each window must be made to open, and it must open at the top. Every habitable room must, further, either have a fireplace and chimney, or a special ventilating aperture or air-shaft with an unobstructed sectional area of at least 100 square inches. Every new building must be provided with adequate means of ventilation, and to secure this the minimum height for dwelling-rooms should be 9 feet in every part, except in attics

used as bedrooms, when a minimum height of 5 feet is permitted, if in two-thirds of the area the height is not less than 9 feet.

7. *Drainage.*—Building sites which are damp must be drained by common earthenware field-pipes properly laid with a suitable outfall, but not directly communicating with any sewer, drain, or cess-pool containing sewage. Rain-pipes and gutters must be provided to carry off all roof-water without causing dampness of the walls or foundations. The level of the lowest storey of the building must be such as to permit of the construction of a drain sufficient for the drainage of the building, and communicating with a sewer into which it may lawfully enter at a point above its centre, or with other means of drainage with which such drain may lawfully communicate. All drains for sewage must be made of impervious pipes, with an internal diameter of at least 4 inches, and be laid in a bed of concrete with a proper fall, and with water-tight joints. No drain must pass under a building except when any other mode of construction is impracticable, and in that case it must be laid in a direct line for the whole distance beneath the house, at a depth in the ground below the surface at least equal to its diameter; be completely embedded in and covered round with concrete 6 inches all round; and be provided with adequate means of ventilation at each end of the portion beneath the building. Every drain inlet, not intended for ventilation, must be efficiently trapped. Every main drain or other drain which may directly communicate with any sewer must be trapped within the curtilage, but as distant as practicable from the building. Every branch drain must join another drain obliquely in the direction of the flow.

At least two untrapped ventilating openings must be provided for the drains, according to one of the following arrangements which will be most suitable under the circumstances (see pp. 281 and 285):—(*a*) One opening at or near the level of the ground must communicate with the drains by means of a suitable pipe, shaft, or right chamber, and situated as near as may be to the trap specified above, but on that side of the trap which is nearer the building. At the other opening must be situated a vertical shaft or pipe to such a height and in such a manner as to prevent any escape of foul air into any building, and in no case to be less than 10 feet; (*b*) where this arrangement is impracticable, the relative positions of these openings may be reversed, the vertical pipe or shaft of a height not less than 10 feet being placed near the trap, and the opening on the ground-level, at the head of the drain. In either case the ground-level opening must be provided with a suitable grating with apertures equal in total area to the sectional area of the drain.

Every pipe or shaft, which may be used in connection with either of these arrangements, whether it be a soil-pipe or not, must have a sectional area of at least 4 inches; and all bends and angles must be avoided as far as practicable.

No drain inlet is permitted within a building except the inlet necessary for a water-closet or slop-sink. Every soil-pipe must be at least 4 inches in diameter, must be placed outside the building, and continued upwards full diameter, without bends or angles, to such a height and such a point as to afford a safe outlet for sewer air. This point must be at least some distance above the eaves of the building to which the soil-pipe is attached, and, where practicable, not less than 3 feet above any window within 20 feet measured in a straight line from the open end of such soil-pipe. There must be no trap between the soil-pipe and the drain, nor in any part of the soil-pipe except such as may be necessary in the construction of the water-closet. The waste-pipe from a slop-sink must conform to the same requirements as a soil-pipe. The waste-pipes from any other sink, bath, or lavatory, the overflow-pipe from any cistern and from any "safe" under a bath or water-closet, and every pipe for conveying waste water, must be taken through an external wall, and must discharge in the open air over a channel leading to a trapped gully-grating at least 18 inches distant (pp. 277-278).

Water-closets must have a window opening directly into the external air, and measuring 2 feet by 1 foot clear of the frame; and, in addition to the window, adequate means of constant ventilation by air-bricks, air-shafts, etc. Such closets, if within the building, must adjoin an external wall. The water must be supplied to a water-closet by means of a special cistern or flushing-box suitable for effectual flushing and cleansing of the basin or pan, which must be made of non-absorbent material, and of such shape and capacity as to receive and contain a sufficient quantity of water, and to allow all filth to fall free of the sides directly into the water. "Containers" and "D-traps" are prohibited (see pp. 266-287).

Earth-closets must be well lighted and ventilated. Proper arrangements must be made for the supply of dry earth, and its effectual and frequent application to the excreta; also for convenience of scavenging, and for exclusion of rainfall and drainage. The receptacle for excreta, whether fixed or movable, must be so constructed as to prevent absorption or escape of the contents, and to exclude rainfall and drainage; if fixed, its capacity must not be greater than may suffice for three months, nor in any case greater than 40 cubic feet, and it must in every part be 3 inches above the ground.

In the case of earth-closets placed inside houses, the maximum capacity of the receptacle may with advantage be reduced to 2 cubic feet, and they are subject to the same conditions as water-closets in respect to position, lighting, and ventilation (see p. 299).

Privies must not be erected within 6 feet of a dwelling, public building, or place of business, nor within 50 feet of any water likely to be used for drinking or domestic purposes. They must be built so as to admit of convenient scavenging without carrying the contents through any dwelling, public building, or place of business. There must be an opening for ventilation at the top; the floor must be paved, and raised 6 inches above the surface of the ground, with a fall of half an inch towards the door. The receptacle may either be fixed or movable. If movable, as in pail-closets, the floor of the area beneath the seat must be flagged or asphalted, and raised 3 inches above the ground-level, and all the sides of the said area must be made of flag, slate, or brick, at least 9 inches thick, and rendered in cement. If the receptacle is fixed, it must be in every part 3 inches above the ground-level, and its capacity should not exceed 8 cubic feet, presuming that the scavenging will be done weekly. Suitable means, or apparatus, must be provided in connection with the privy for the application of ashes, dust, or dry refuse to the filth deposited, and the receptacle must be so constructed that the contents may not at any time be exposed to rainfall, or to the drainage of any waste water or liquid refuse from any adjoining premises, while at the same time conveniently accessible for scavenging. The materials and construction must be such as to prevent any absorption by any part of it of any filth deposited therein, or any escape by leakage or otherwise of its contents. It must not be connected with a drain (see p. 297).

Cess-pools must not be constructed within 50 feet of any dwelling, public building, or place of business, nor within 100 feet of any water likely to be used for drinking or domestic purposes. They must be constructed and situated so as to admit of convenient scavenging; must not be connected with any sewer; and must be properly covered over with manhole cover or arch and adequately ventilated. They must be constructed of brick laid in cement, and with a backing of clay-puddle at least 9 inches thick (see p. 286).

Ash-pits must not be constructed within 6 feet of a dwelling, nor within 50 feet of any water likely to be used for drinking purposes, and generally they must be constructed on the same lines as those applying to the fixed receptacles. (Section 11 of the Public Health Acts (Amendment) Act, 1890, defines *ash-pit* as including any ash-tub or bin for privies.)

Closure of Premises.—Under certificate of the medical officer of health or surveyor, the sanitary authority may declare any building or part thereof,

to be . . . unfit for habitation, and order it to be closed until rendered fit for habitation.

Plans and Sections must be submitted to the sanitary authority showing in proper detail the construction of all proposed new streets or buildings, or any material alterations thereof.

Inspection and Supervision.—Notice must be given to the surveyor of the district of the dates upon which work is to be commenced, and of the dates upon which any sewer, drain, or foundation is to be covered up; and notice must also be given of the completion of the work.

Demolition of Works.—If any work to which these bye-laws apply is done in contravention of such bye-laws, the sanitary authority are empowered to remove, alter, or pull down such work.

In **London,** the planning and laying out of new streets and the construction of new buildings are governed, with certain exceptions applying to the City, by the provisions of the London Building Act, 1894, while the sanitary requirements of houses, the construction of underground rooms, and the structure of premises in which any offensive trade is carried on, are regulated by the provisions of the Public Health (London) Act, 1891, and the bye-laws authorised by them. The powers are vested in the local authorities, but the County Council have certain powers conferred upon them by the Building Act, 1894, to increase the width of new streets, not within two miles of St. Paul's Cathedral, and to refuse to sanction plans for streets formed for carriage traffic, and those formed for foot traffic, unless the former is at least 40 feet wide, and the latter 20 feet clear. They have also power, under certain conditions, to move back buildings which project, and to prevent the erection of new buildings so as to project beyond the frontage line of the street. In order still further to minimise the evil effects of surface crowding, and to secure proper ventilation in and around buildings, the application of the principle of measurement by angles for the determination of the height in relation to the space required at the rear of houses is laid down in the 1894 Act, and all bye-laws relating thereto, as well as the thicknesses of walls in relation to height, and the proper sanitary requirements of new and old buildings, authorised by the Public Health (London) Act, 1891, are carried out under the supervision of district surveyors appointed by the County Council. These struc-

tural details, though more comprehensive, conform in most essentials with the general rules contained in the Model Bye-Laws of the Local Government Board.

In **Scotland,** so far as burghs are concerned, the Burgh Police (Scotland) Act, 1892 (Sections 166-180, and 201-209), confer extensive powers on the Burgh Commissioners with respect to new streets and buildings, and bye-laws relating thereto. There is prohibition of the erection of buildings upon polluted sites, and the principal distinctions as to other requirements are the following:—

(*a*) All rooms in new or altered dwellings must be sufficiently lighted and ventilated from the street, or from an open space equal to three-fourths of the area in which the house stands; (*b*) not more than twelve flat tenements may open from an inside stair, nor more than twenty-four from an outside stair; (*c*) rooms on the ground-floor in new dwellings must be $9\frac{1}{2}$ feet in height, and on other floors 9 feet, with the exception of attics, which must be 8 feet in height over one-third of their area, and nowhere less than 3 feet; (*d*) all new rooms of less area than 100 feet, and built without a fireplace, must be provided with special means of ventilation. Common stairs must be efficiently ventilated.

As regards districts, other than burghs, Section 181 (1) of the Public Health (Scotland) Act, 1897, empowers the local authority to make bye-laws, subject to the approval of the County Council for the whole or any part of their district, "for regulating the building or rebuilding of houses or buildings, or the use for human habitation of any building not previously so used, or any alteration in the mode of occupancy of any existing house in such a manner as will increase the number of separate houses in respect to the following matters":—

(*a*) The drainage of the subsoil of sites for and the prevention of dampness in houses intended for human habitation;
(*b*) The structure of walls, foundations, roofs, and chimneys of new buildings in so far as likely to affect human health;
(*c*) The ventilation of houses and buildings intended for human habitation;
(*d*) The sufficiency of the space about buildings to secure a free circulation of air;
(*e*) The construction and arrangement of the drainage of houses

and buildings and of soil-pipes and waste-pipes, and the construction and position of water-closets, earth-closets, privies, ash-pits, cess-pools, dungsteads, slop-sinks, and rain-water pipes and rhones;

(*f*) The production of suitable building plans in respect of the matters in this section mentioned, and their inspection;

(*g*) The intimation previous to the commencement by the owner or person laying out the work to the local authority of the date of the commencement, and for the due inspection, in respect of the matters in this section mentioned, of houses or buildings in process of erection or alteration, and the examination of the drains thereof, and for the pulling down, alteration, or amendment of any work which has been carried out in contravention of the bye-laws.

(2) In making such bye-laws, the local authority shall have regard to the special circumstances of their district, or the part thereof to which such bye-laws relate.

Section 182 prohibits the erection of a new building on filled-up ground impregnated with animal or vegetable matter, unless such matter has been removed or otherwise become innocuous, under a penalty not exceeding £5, or a daily penalty not exceeding 40s.

It will be seen from the above that the powers conferred on local authorities in Scotland in respect to buildings are much more explicit and drastic than those applying to the rural districts in England, many of which are still without building bye-laws of any kind, unless they have applied for urban powers or adopt Part III. of the Public Health Acts (Amendment) Acts, 1890.

In **Ireland,** Sections 38 and 39 of the Public Health (Ireland) Act empower urban authorities to purchase premises for the widening or improvement of streets, and to regulate the line of buildings; while under Section 41 both urban and rural authorities have powers to make bye-laws in respect to the same matters as are conferred on English urban authorities by Section 157 of the 1875 Act, but no bye-laws are applicable to buildings erected prior to the passing of the Act. Sections 44-51 contain such full provisions applying to urban and rural districts, with regard to water-closets, earth-closets, drains, etc., that, though Section 23 of the Public Health Acts (Amendment) Act, 1890, extends to Ireland, its provisions are scarcely required, but

that Act, or parts of it, can be generally adopted wherever deemed necessary.

XXI.—Parks, Open Spaces, and Commons

Under Section 164 of the Public Health Act, 1875, *urban* sanitary authorities are empowered to provide and regulate, by means of bye-laws, public parks and pleasure grounds. (By adoption of Part III. of the Public Health Acts (Amendment) Act, 1890, they are also empowered to close them on certain days, and grant their use, either gratuitously or on payment, to any public charity, institution, society, or show. Under Section 64 of the 1890 Act they are further empowered to contribute towards the cost of laying out, planting, or improving, or of purchasing lands for public parks or pleasure grounds.)

(Section 8 (1) of the Local Government Act, 1894, confers upon parish councils such powers as may be exercised by urban authorities under Section 164 of the 1875 Act with respect to any recreation ground, village green, open space, or public walk for the time-being under their control, and to the expense of which they have contributed.)

The Open Spaces Act, 1877, gave additional facilities to all urban and rural authorities, invested with powers of the Act by order of the Local Government Board, for the acquisition, maintenance, and regulation of open spaces, including disused burial-grounds, for the use of the public.

In **London**, under the Metropolis Open Spaces Acts of 1877, 1881, and 1887, powers are conferred on the County Council and Corporation of the City to acquire, maintain, and regulate open spaces and disused burial-grounds under their jurisdiction, and make bye-laws. Such powers and duties may also be exercised by any vestry or district board; and they have powers to rate inhabitants of squares, crescents, etc., for maintenance of gardens. The Gardens in Towns Protection Act, 1863, further enables the County Council and the Corporation of the City to take over, on the request of the persons entitled thereto, the right to acquire any garden or ornamental ground, to be kept and maintained as such.

In respect to schemes, the County Council, under the Metropolitan Commons Act, 1878, have powers to oppose enclosure of any common situate within the metropolis, and also to purchase and hold, with a view to prevent the

extinction of common rights, any saleable rights in common; while the Corporation of the City, under the Corporation of London (Open Spaces) Act, 1878, can acquire by purchase, gift, or otherwise, the freehold or interest in common lands, including all rights, not within the Metropolis Management Act, but within twenty-five miles of the city.

In **Scotland,** local authorities are empowered by the Public Parks (Scotland) Act, 1878, and the Secretary of Scotland Act, 1885, to purchase or take on lease, lay out, and maintain lands as parks, public walks, or pleasure grounds, as well as to borrow and impose rates for the purpose, and regulate by bye-laws; while the Burgh Police Act of 1892 confers powers on Burgh Commissioners of acquiring land for these purposes within two miles of their outside boundaries. They have also powers to defend and maintain rights in common or open spaces, and make bye-laws.

In **Ireland,** the Open Spaces Act, 1887, confers similar powers on authorities as are conferred by Section 164 of the Public Health Act of 1875 applying to England, while these powers can be extended by the adoption of Part III. of the Public Health Acts (Amendment) Act, 1890. Additional powers are conferred on urban authorities of towns with a population exceeding 6000 by the Towns Improvement Act, 1854, and the Public Parks (Ireland) Act, 1869, with respect to borrowing, rating, and making bye-laws. The Open Spaces Act of 1887 enables authorities to deal with disused burial-grounds for the purposes of the Act.

XXII.—Baths and Wash-Houses

The Baths and Wash-Houses Act of 1846 empowered every borough and populous parish in England to provide public baths and wash-houses for the use of the inhabitants subject to the approval of the Secretary of State, and to make regulations for the same. The Amending Act of 1847 fixed a definite scale of charges, and the Local Government Act of 1871 transferred the functions of the Secretary of State in respect to both Acts to the Local Government

Board. Section 10 of the Public Health Act, 1875, now gives power to urban authorities to adopt and act under those statutes to the exclusion of any other authority. Another amending Act, namely, The Baths and Wash-Houses Act of 1878, extended all the provisions of the two previous Acts to covered swimming-baths, as well as to baths, wash-houses, and open bathing-places.

By Section 5 of this Act power is given to an urban authority to close any covered or open swimming-bath for a period during each year not exceeding five months, from the beginning of November to the end of March, and they may either keep the same closed or use it for a gymnasium, or for any other purpose of healthful recreation.

The Baths and Wash-Houses Acts, 1892, extended the powers of purchase or leasing, etc., conferred by the 1846 Act, to any place "in the immediate neighbourhood of such borough or parish." (In rural parishes the Acts 1846 to 1882 can only be adopted by the parish meeting, and Section 7 (1) of the Local Government Act, 1894, appoints the parish council the authority to carry them into effect.) Where the Acts have been adopted, the expenses incurred in their execution, if the baths and wash-houses are not self-supporting, will be borne in the same manner as expenses under the Public Health Act, 1875. Bye-laws may be made by the controlling authority.

(The Cleansing of Persons Act, 1897, empowers sanitary authorities throughout the United Kingdom, to provide cleansing and disinfection for persons, other than paupers, infested with vermin.)

In **London,** the Baths and Wash-Houses Acts may be adopted in any metropolitan parish by the vestry, subject to the approval of the Local Government Board, and when adopted, commissioners must be appointed by the vestry to carry out the provisions of the Acts. In the City the Commissioners of Sewers are empowered by their Baths and Wash-Houses Act of 1895, under the Acts 1846 to 1882, to erect, acquire, regulate and control by bye-laws such baths and wash-houses as they may deem necessary.

In **Scotland,** these Acts do not apply, so that the authorities, other than those of burghs, have no power to provide such accommodation. But in burghs the commissioners have full power to provide and regulate such places under Sections 309-314 of the Burgh Police Act, 1892, subject to the condition that there must be double

the amount of bathing accommodation provided for the working classes which may be provided for the better class.

In **Ireland**, the only Act in force is that of 1846, which is practically the same as that applying to England. Under the Public Health (Ireland) Act, 1878, urban authorities who have adopted the Act become the controlling authorities. In rural parts, the Act can only be put in force in towns which are not urban districts. Commissioners of towns constituted under the Towns Improvement (Ireland) Act, 1854, have also certain powers to provide baths and wash-houses, and regulate the same.

XXIII.—Unsound Food

Under Section 116 of the Public Health Act, 1875, "the medical officer of health or inspector of nuisances may at all reasonable times examine or inspect any *animal*, *carcase*, *meat*, *poultry*, *game*, *flesh*, *fish*, *fruit*, *vegetables*, *corn*, *bread*, *flour*, or *milk* exposed for sale, or deposited in any place for the purpose of sale, and intended for the food of man, the proof that the same was not deposited for any such purpose, or was not intended for the food of man, vesting with the party charged; and if any such *animal*, *carcase*, etc., appears to be diseased or unsound or unwholesome, and unfit for the food of man, he may seize and carry away the same himself, or by an assistant, in order to have the same dealt with by a justice."

Section 117 provides that "if it appears to the justice that any *animal*, *carcase*, *meat*, etc., so seized is diseased, or unsound, or unwholesome, or unfit for the food of man, he *shall condemn the same*, and order it to be destroyed or so disposed of as to prevent it from being exposed for sale or used for the food of man; and the person to whom the same belongs or did belong at the time of exposure for sale, or in whose possession or on whose premises the same was found, shall be liable to a penalty not exceeding *twenty pounds* for every animal, carcase, or fish, or *piece of meat*, flesh, or fish, or any poultry or game, or for the parcel of fruit, vegetables, corn, bread, or flour, or for the milk so condemned, or, at the discretion of the justice, without the infliction of a fine, to imprisonment for a term of not more than *three months*."

Any person who prevents a medical officer of health or inspector of nuisances from entering any premises for the purpose of inspecting any animal, carcase, etc., or who obstructs or impedes such officer or his assistant when carrying out the provisions of the Act, shall be liable to a penalty not exceeding £5 (Section 118). On complaint being made on oath by a medical officer of health or other officer of a local authority,

a justice may grant a warrant to enter, search, and seize, and any one who obstructs is liable to a penalty not exceeding £20.

It will be observed that in the foregoing provisions there are two defects, namely, that no proceedings can be taken in respect to articles of food already sold, and that there are important articles, such as butter, cheese, eggs, and many others, which are not specifically mentioned, and are therefore not included in the scope of these sections. But these defects have been remedied so far as districts which have adopted Part III. of the Public Health Acts (Amendment) Act, 1890, are concerned, inasmuch as Section 28 of that Act provides that Sections 116-119 of the 1875 Act shall extend to "any article *intended* for the food of man, sold or exposed for sale," and proceedings can be taken as above. Additional protection is also afforded by Section 15 of the Market and Fairs Clauses Act, 1847, incorporated with the 1875 Act, which enacts that "any person who shall sell or expose for sale any unwholesome meat or provisions in the market or fair, shall be liable to a penalty not exceeding £5 for every such offence." This section, however, can only apply to districts in which markets and fairs are under the control of the sanitary authority, or where a local Act is in force, but in all such districts the authority can make bye-laws for the prevention of the sale of unsound food by Section 42 of the Act of 1847, which is also incorporated with the Public Health Act of 1875.

It should also be noted that diseased animals can be seized under Section 111 of the 1875 Act if exposed for sale. In respect to butcher meat or other articles of food, although it is not necessary to give notice to the owner, if he is not present, of the articles seized, it is always advisable to do so when possible, in order to afford him the opportunity of requesting any one else to examine the carcase, meat, etc., before it is destroyed. As regards the expression "any reasonable time," it has been ruled by the courts to include Sundays. In the event of seizure, it is necessary to take the article of food before a justice with the least possible delay, because during warm weather there are several

articles, and butcher-meat especially, which rapidly become putrid or tainted, apart from being otherwise unsound or diseased.

The diseases which render the flesh of animals unfit for the food of man have already been discussed in Chapter II. (see pp. 34-48), and directions for the examination of butcher-meat and other articles have been given in Section 5 of the same chapter (see pp. 48-52).

Very often, with regard to bad meat, the defence set up is that such meat was not intended for the food of man, but for feeding dogs, or to be boiled down with other offal as the case may be. So far, however, as the medical officer of health is concerned, he should endeavour, as far as possible, to confine his evidence to the question as to whether the meat seized by the inspector is or is not fit for the food of man, and whether it appears to him to have been dressed in the usual way, leaving the rest of the evidence to be given by the sanitary inspector or other witnesses. Should the medical officer of health deem it to be his duty to himself seize, he should call in the assistance of the sanitary inspector, or a policeman, or some other person, to have the carcase, meat, etc., so seized to be removed, in order that it may be dealt with by a magistrate. It need hardly be said that it is always advisable to take careful notes of all the points on which he bases his opinion that the meat, etc., submitted to him for inspection, or which he may himself seize, is unfit for the food of man, and these notes he can use when he gives his evidence in court.

In **London,** under Section 47 of the Public Health (London) Act, 1891, the provisions as to the sale of unsound food are much more comprehensive and stringent than those contained in the 1875 Act, inasmuch as it includes "(*a*) any animal intended for the food of man which is exposed for sale or deposited in any place for the purpose of sale, or of preparation for sale; and (*b*) any article, whether solid or liquid, intended for the food of man, and *sold* or exposed for sale, or deposited in any place for the purpose of sale or of preparation for sale." The section further renders the

offender liable on conviction to a fine not exceeding £50 or imprisonment for six months, with or without hard labour, and if the offender is the occupier of a licensed slaughter-house, the court may cancel the license. It also imposes a severe penalty for obstruction, and renders the previous vendor liable. On written notice from the owner, the sanitary authority is bound to remove unsound food, as if it were trade refuse.

In **Scotland,** the provisions as set forth in Section 43 (1) of the Public Health (Scotland) Act, 1897, are still more drastic, and are as follows :—

"Any medical officer or sanitary inspector, or any veterinary surgeon approved for the purposes of this section by the local authority, may at all reasonable times enter any premises within the district of the local authority, or search any cart or vehicle, or any barrow, basket, sack, bag, or parcel, in order to inspect and examine and may inspect and examine

(*a*) Any animal, alive or dead, intended for the food of man which is exposed for sale, or deposited in any place, or is in course of transmission for the purpose of sale, or of preparation for sale ; and

(*b*) Any article, whether solid or liquid, intended for the food of man, and sold or exposed for sale, or deposited in any place or in course of transmission for the purpose of sale or of preparation for sale,

the proof that the same was not exposed or deposited or in course of transmission for any such purpose, or was not intended for the food of man, resting with the person charged ; and if any such animal or article appears to such medical officer or sanitary inspector or veterinary surgeon to be diseased, or unsound, or unfit for the food of man, he may seize and carry away the same himself or by an assistant, in order to have the same dealt with summarily by a sheriff, magistrate, or justice.

Provided that in the case of any proceeding under this section with regard to a living animal the medical officer or sanitary inspector, unless he is himself a qualified veterinary surgeon, shall be accompanied by a veterinary surgeon approved as aforesaid.

The police force of each police area shall have power to search carts or vehicles, or barrows, baskets, sacks, bags, or parcels, and to assist generally in executing and enforcing this section."

Sub-section (2) renders the offender liable to imprisonment with or without hard labour for a term not exceeding three months. Sub-section (3) empowers a local authority, or two or more authorities jointly, to appoint a veterinary surgeon, and fix times and places, in order that he may examine any animal alive or dead, for a stated fee

to be paid by the owner, and if the same is passed, he must grant a certificate with full particulars, but in the case of a dead animal the whole carcase including the viscera must be submitted. Sub-section (4) renders the previous vendor liable to a fine or imprisonment if the animal or article when sold was found to be unsound. Sub-section (5) enacts that the veterinary surgeon shall forward forthwith a copy of the certificate to the chief constable of the jurisdiction in which the examination is made, and the certificate itself shall be forwarded within seven days to the chief constable of the place in which the sale of the animal or carcase took place, under a penalty in either case not exceeding £20. Sub-section (6) enacts that on a second proved offence, the sheriff, magistrate, or justice may order a notice of all the facts to be affixed to the premises of the offender for a period not exceeding 21 days, the costs of the affixing to be paid by the offender, and a liability to a fine not exceeding £5 is incurred if he interferes with such notice. Sub-section (7) gives power to cancel a slaughter-house license on conviction, and (8) imposes severe penalties for obstruction.

Under Sections 428-429 of the Burgh Police (Scotland) Act, 1892, a local authority has power to seize and destroy diseased cattle, whether offered for sale or not, and to take proceedings against the original vendors of diseased meat or animals intended for human food, whether within or without the burgh.

In **Ireland,** by Sections 132-135 of the Public Health (Ireland) Act, 1878, the provisions for dealing with unsound food are set forth on lines similar to those contained in the 1875 Act, but *butter* is added to the list of articles of food categorically stated. The defects in the Act can be remedied in all districts by adopting Part III. of the Public Health Acts (Amendment) Act, 1890. Section 15 of the Markets and Fairs Clauses Act, 1847, incorporated in the Public Health (Ireland) Act, applies only to urban districts, and Section 103 of the latter Act enables an urban authority to make bye-laws *inter alia* to prevent the sale or exposure for sale of unsound food in any market belonging to them.

XXIV.—Horseflesh

The Sale of Horseflesh, etc., Regulation Act, 1889, which applies to Great Britain and Ireland, provides that horseflesh shall not be sold for human food elsewhere than in a

shop, stall, etc., conspicuously labelled as a place where horseflesh is sold, and it gives the medical officer of health and sanitary inspector, or "any other officer" appointed by the local authority, powers of entry, inspection, and seizure. "Horseflesh" includes the flesh of "asses and mules," and means "horseflesh" cooked or uncooked, alone or in combination with any other substance, and the Act also prohibits the sale of horseflesh as food to any purchaser asking for other meat or for a compound article not usually made of horseflesh. In respect to procedure and legal proceedings, the provisions are similar to those already described as applying to the different countries as regards unsound food. The penalty incurred for a breach of the Act is a fine not exceeding £20.

XXV.—Adulteration of Food and Drugs

The Acts dealing with adulteration are the Sale of Food and Drugs Act, 1875; the Sale of Food and Drugs (Amendment) Act, 1879; the Margarine Act, 1887; and, in respect to the administration of these Acts in England and Wales, the Local Government Act of 1888. The Acts apply to the whole of the United Kingdom.

Section 2 of the Act of 1875 defines *food* as including every article used as food or drink by man other than drugs or water, and *drug* as including medicine for external or internal use (Section 2). Under Section 3 it is enacted that no article of food shall be mixed or treated so as to render the article injurious to health with the intent that the same may be sold in that state; while Section 4 enacts similar provisions in respect to any drug, and for an infringement of either of these sections a penalty not to exceed £50 for a first offence is incurred. Section 5 provides that there shall be no penalty incurred if the accused can show that he was unaware of the adulteration. Section 6 provides that no person shall sell to the prejudice of the purchaser any article of food or drug which is not of the nature, quality, and substance asked for, under a penalty, but no offence shall be deemed to be committed in the following cases:—(1) Where any matter or ingredient not injurious to health has been added to the food or drug because the same is required for the preparation or production thereof as an article in a state fit for carriage or consumption, and not with intent to increase the bulk, or in any way defraud, or conceal the inferior

quality thereof; (2) where the food or drug is a proprietary medicine, or is the subject of a patent, and is supplied according to the patent; (3) where the food or drug is properly compounded; and (4) where the food or drug is unavoidably mixed with any extraneous matter in the process of collection or preparation. Section 7 enacts that no person shall sell any compound, drug, or article of food which is not composed of ingredients in accordance with the demand of the purchaser under a penalty; but, according to Section 8, no offence is committed in respect of the sale of a drug or article of food mixed with an ingredient not injurious to health if it is labelled as mixed at the time of sale. Section 9 provides that no person shall abstract from an article of food any part of it, so as to affect injuriously its quality, substance, or nature; and no person shall sell any article so altered without making disclosure of the alteration under a penalty.

Section 10 refers to the appointment of public analysts. In the case of boroughs having a separate court of quarter sessions, or a separate police force, the appointment is made by the town council.

(In the administrative counties, the Local Government Act of 1888 provides that it shall be made by the County Council, but all appointments are subject to the approval of the Local Government Board.)

Section 12 provides that any person shall be entitled to have any drug or article of food purchased by him in his own sanitary district analysed by the analyst for that district at a fee not exceeding 10s. 6d., and to receive a certificate with the result of the analysis. Section 13 enacts that the medical officer of health, sanitary inspector, or any other officer appointed by the local authority with the execution of the Act may procure samples of food and drugs and submit them to the public analyst. Any person purchasing an article for analysis shall, upon the completion of the purchase, forthwith notify to the seller his intention to have it analysed by the public analyst; and shall offer to divide it into three parts, to be then and there separated, and each part to be marked or sealed or fastened up, and shall, if required to do so, proceed accordingly, and shall deliver one of the parts to the seller, another he shall retain for comparison, and deliver the third to the analyst (Section 14). According to Section 15, if the seller do not accept the offer of division, the analyst must divide the article into two parts, and seal up and deliver one of them to the purchaser. Section 16 provides that samples may be sent to the analyst by post in a registered letter, if his residence is two miles from that of the purchaser. (This section is amended by Section 2 of the Post Office Act of 1891, under which the words "registered parcel" are to be substituted for "registered letter," so that samples can now be forwarded to the public analyst by parcel post.)

Section 17 enacts that any person refusing to sell to an officer of the local authority any article of food or drug on sale by retail, the price being tendered, and the quantity demanded not being greater

than is reasonably requisite, is liable to a penalty not exceeding £10. The justices before whom a case is heard may, at the request of either party, cause any article of food and drug to be sent to the Commissioners of Inland Revenue for analysis by the chemists of their department at Government House (Section 22). It is provided by Section 24 that, as regards all the exemptions under Section 6, the onus of proof rests with the defendant; while Section 25 provides that in any prosecution under this Act the defendant is to be discharged if he proves to the satisfaction of the court (1) that he bought the article as being the same in nature, substance, and quality with that demanded by the purchaser, and with a written warrant to that effect; (2) that at the time of sale he had no reason to believe it to be otherwise; and (3) that he sold it in the same state as he purchased it.

This Act was amended by the Act of 1879, in order to settle some disputed points which had arisen in carrying out the 1875 Act.

Section 2 of the 1879 Act provides that it shall be no defence to allege that the purchaser is not prejudiced by the sale of an adulterated article, on the ground that he bought it for analysis only; or to allege that the article in question, though defective in nature, substance, or quality, was not defective in all three respects. According to Section 3, the officer charged with the execution of the Act may procure, *at the place of delivery*, a sample of milk in course of delivery to the purchaser or consignee in pursuance of any contract, and may submit the sample to the public analyst; while Section 4 renders the seller, or his representative, liable to a penalty not exceeding £10 if he refuses to allow a sufficient sample to be taken. Section 6 provides that as regards spirits not adulterated otherwise than by admixture of water, it is a good defence to prove that the admixture has not reduced the spirit more than 25 degrees under proof for brandy, whisky, or rum, or 35 degrees under proof for gin.

In a circular addressed to sanitary authorities in 1894, the Local Government Board recommends that the following rules suggested by the chemical officers of the Inland Revenue should be observed in forwarding samples in accordance with the provisions of the 1875 Act:—

1. The quantities of the samples purchased under Section 13 should not be less in the case of milk than 1 pint, butter $\frac{3}{4}$ of a lb., lard $\frac{3}{4}$ of a lb., coffee $\frac{3}{4}$ of a lb., spirits $\frac{3}{4}$ of a pint.

2. The division under Section 14 should be made as nearly equal as possible, so that the portion reserved may be not less than one-third of the whole.

3. The reserved portion of such samples as butter and lard should, so soon after purchase as possible, be placed without paper (since paper acts as an absorbent) in a dry, wide-mouthed, stoppered bottle, or in an earthenware jar, securely corked so as to exclude air.

4. The bottle used for the reserved portion of milk should be of such capacity that the milk may nearly fill it.

5. The corks should be new and sound.

XXVI.—Margarine

In order to prevent the fraudulent sale of margarine, which is largely manufactured from animal fats, and closely resembles butter in appearance and taste, the Margarine Act of 1887 was passed.

This Act defines "margarine" as including all substances, whether compounds or otherwise, prepared in imitation of butter or not. Section 6 enjoins that every person dealing in margarine must observe the following regulations:— Every package containing margarine, whether open or closed, must be branded or durably marked "margarine" on the top, bottom, and sides, in printed capital letters not less than $\frac{3}{4}$ inch square; and if such margarine be exposed for sale by retail there must be attached to each parcel thereof so exposed, and in such manner as to be clearly visible to the purchaser, a label marked in printed letters not less than $1\frac{1}{2}$ inches square "margarine"; and every person selling margarine by retail, save in a package duly branded or marked as above, must in every case deliver it to the purchaser in or with a paper wrapper on which is printed "margarine" in capital letters not less than $\frac{1}{4}$ inch square. All margarine, whether imported or manufactured in this country, must be duly consigned as "margarine" (Section 8). All manufactories of margarine must be registered with the local authority appointing the public analyst (Section 9). Any officer authorised to take samples under the Sale of Food and Drugs Act may, without going through the form of purchase provided by that Act (see *ante*, p. 692), but otherwise acting in all respects in accordance with the provisions of the said Act as to dealing with samples, take for the purposes of analysis samples of any butter, or substances purporting to be butter, which are exposed for sale, and are not marked "margarine," as provided by this Act; and such substance not being so marked shall be presumed to be exposed for sale as butter (Section 10). Every person dealing in margarine, whether wholesale or retail, who is found guilty of an offence under this Act is liable on conviction to a penalty not exceeding £20 for the first offence, £50 for the second, and £100 for the third or any subsequent offence (Section 4). Any part of these penalties may, if the court so direct, be paid to the person who proceeds for the same

to reimburse for costs and reasonable expenses, but a saving clause is provided to the effect that the vendor is absolved if he can prove by a written warranty that he purchased the article as butter, and that he sold it in the same state as he received it, believing it to be butter (Section 11).

XXVII.—Cow-Sheds, Dairies, and Milk-Shops

The first Order regulating milk-supplies was issued by the Privy Council in 1885, in pursuance of Section 34 of the Contagious Diseases (Animals) Act of 1878. In 1886 an amending Act was passed transferring the powers of the Privy Council under this section to the Local Government Board, and imposing the duty of supervising the milk-trade in their districts on every urban and rural authority (Section 9 of the 1886 Act). The powers thus conferred on the Local Government Board enable them to make general or special Orders for—(1) the registration with the local authority of all persons carrying on the trade of cow-keepers, dairymen, or purveyors of milk; (2) the inspection of cattle in dairies and regulation of the sanitary condition of cow-sheds and dairies; (3) securing the cleanliness of milk-stores, shops, and vessels containing milk; (4) protecting milk against infection; and (5) authorising sanitary authorities to make regulations for any or all of the aforesaid purposes. The chief provisions of the Order of 1885, as amended by that of 1886, issued by the Local Government Board, are as follows:—

Registration of Dairymen and Others.

Section 6. (1) It shall not be lawful for any person to carry on in the district of any local authority the trade of cowkeeper, dairyman, or purveyor of milk unless he is registered as such in accordance with this article. (2) Every local authority shall keep a register of persons from time to time carrying on in their district the trade of cow-keepers, dairymen, or purveyors of milk, and shall from time to time revise and correct the register. (3) The local authority shall register every such person, but the fact of such registration shall not be deemed to authorise such person to occupy as a dairy or cow-shed any particular building, or in any way preclude any proceedings being

taken against such person for non-compliance with or infringement of any of the provisions of this Order, or any regulation made thereunder. (4) The local authority shall from time to time give public notice of registration being required, and of the mode of registration. (5) A person who carries on the trade of cow-keeper or dairyman for the purpose only of making and selling butter or cheese, or both, and who does not carry on the trade of purveyor of milk, need not be registered. (6) A person who sells milk of his own cows in small quantities to his workmen or neighbours for their accommodation need not, by reason thereof, be registered.

Construction and Water-Supply of New Dairies and Cow-Sheds.

Section 7. (1) It shall not be lawful for any . . . cow-keeper or dairyman to begin to occupy as a dairy or cow-shed any building not so occupied at the commencement of this Order . . . until he first makes provision, to the reasonable satisfaction of the local authority, for the lighting and ventilation, including air-space, and the cleansing, drainage, and water-supply of the same. . . . (2) It shall not be lawful for any such person to begin so to occupy any such building without first giving one month's notice in writing to the local authority of his intention so to do.

Sanitary State of all Dairies and Cow-Sheds.

Section 8. It shall not be lawful for any . . . cow-keeper or dairyman to occupy as a dairy or cow-shed any building—whether so occupied at the commencement of this Order or not—if . . . the lighting and ventilation, including air-space, and the cleansing, drainage, and water-supply thereof, are not such as are necessary or proper (*a*) for the health and good condition of the cattle therein; and (*b*) for the cleanliness of milk-vessels used therein for containing milk for sale; and (*c*) for the protection of the milk therein against infection or contamination.

Section 9. It shall not be lawful for any . . . cow-keeper, or dairyman, or purveyor of milk, or occupier of a milk-shop (*a*) to allow any person suffering from a dangerous infectious disorder, or having recently been in contact with a person so suffering, to milk cows or to handle vessels used for containing milk for sale, or in any way to take part or assist in the conduct of the trade . . . so far as regards the production, distribution, or storage of milk; or (*b*) if himself so suffering, or having recently been in contact as aforesaid, to milk cows or handle vessels containing milk for sale, or in any way to take part in the conduct of his trade as far as regards the production, distribution, or storage of milk; until, in each case, all danger therefrom of the communication of infection to the milk or of its contamination has ceased.

Section 10. It shall not be lawful for any person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, after the receipt of notice of not less than one month from the local authority calling attention to the provisions of this article, to permit any water-closet, earth-closet, privy, cess-pool, or urinal to be within, communicate directly with, or ventilate into, any dairy or any room used as a milk-store or milk-shop.

Section 11. It shall not be lawful for any person following the trade of cow-keeper, or dairyman, or purveyor of milk, or being the occupier of a milk-store or milk-shop, to use a milk-store or milk-shop in his occupation, or permit the same to be used, as a sleeping apartment, or for any purpose incompatible with the proper preservation of the cleanliness of the milk-store or milk-shop, and of the milk-vessels and milk therein, or in any manner likely to cause contamination of the milk therein.

Section 12. It shall not be lawful for any person following the trade of a cow-keeper, or dairyman, or purveyor of milk, to keep any swine in any cow-shed or other building used by him for keeping cows, or in any milk-store or other place used by him for keeping milk for sale.

Regulations of Local Authority.

Section 13. A local authority may from time to time make regulations for the following purposes, or any of them:—(*a*) For the inspection of cattle in dairies. (*b*) For prescribing and regulating the lighting, ventilation, cleansing, drainage, and water-supply of dairies and cow-sheds. . . . (*c*) For securing the cleanliness of milk-stores, milk-shops, and of milk-vessels used for containing milk for sale. (*d*) For prescribing precautions to be taken by purveyors of milk and persons selling milk by retail against infection or contamination.

Provisions as to Regulations of Local Authority.

Section 14. The following provisions shall apply to regulations made by a local authority under this Order:—(1) Every regulation shall be published by advertisement in a newspaper circulating in the district of the local authority. (2) The local authority shall send to the Local Government Board a copy of every regulation made by them not less than one month before the date named for such regulation to come into force. (3) If at any time the Local Government Board are satisfied, on inquiry, with respect to any regulation, that the same is of too restrictive a character, or otherwise objectionable, they may direct the revocation thereof, and the same shall not come into operation, or shall thereupon cease to operate, as the case may be.

Existence of Disease among Cattle.

Section 15. If at any time disease exists among the cattle in a dairy or cow-shed, or other building or place, the milk of a diseased cow there-

in—(*a*) shall not be mixed with other milk, and (*b*) shall not be sold or used for human food, and (*c*) shall not be sold or used for food of swine, or other animals, unless and until it has been boiled.

Penalties.

The penalties imposed for every offence against these provisions are a fine not exceeding £5, and an additional daily penalty of 40s. for a continuing offence (Amending Order, 1886).

For the purpose of enforcing the Orders of the Local Government Board or any regulations thereunder, sanitary authorities or their officers have the same rights of entry and inspection as they possess in respect to nuisances. Any expenses incurred in the execution of the Acts are to be defrayed as if they were incurred in the execution of the Public Health Act, 1875, and in the case of rural authorities are to be deemed general expenses.

In districts where the Infectious Disease (Prevention) Act, 1890, has been adopted, the following important section of that Act applies in respect to infected milk-supplies.

Section 4 enacts that if the medical officer has reason to believe that any person in his district is suffering or likely to suffer from infectious disease attributable to milk supplied within his district, from any dairy situate within or without his district, he may, if authorised by a justice having jurisdiction in the place where the dairy is situate, inspect such dairy. He is further empowered, if accompanied by a veterinary surgeon, to inspect the animals in such dairy, and if he is of opinion that infectious disease is caused by consumption of the milk, he must report to the authority, and at the same time forward any report furnished to him by the veterinary surgeon. The authority may thereupon give not less than twenty-four hours' notice to the dairyman to appear before them, and show cause why an order should not be made requiring him not to supply any milk from the dairy until such order has been withdrawn. If in their opinion he fails to show cause, the authority may order accordingly, but notice of the facts must forthwith be given by the local authority to the sanitary authority and County Council of the district or county in which the dairy is situate, and also to the Local Government Board. The order, however, must be forthwith withdrawn on the local authority or medical officer of health being satisfied that the milk-supply has been changed, or that the cause of infection has been removed. Any one refusing to permit the medical officer of health to inspect any dairy on the production of such order aforesaid, or who,

after order has been given to prohibit the supply, disobeys such order, shall be deemed guilty of an offence under the Act, provided that proceedings shall be taken before the justices having jurisdiction in the place where the dairy is situate, and provided also that no dairyman shall be liable for breach of contract if the breach be due to an order under this Act.

In **London,** Section 28 of the Public Health (London) Act, 1891, practically repeals Section 34 of the Contagious Diseases (Animals) Act, 1878, as well as Section 9 of the 1886 Act, and confers the same powers on the Local Government Board to issue orders and regulations as were given under those sections, and on the County Council and Corporation of the City, to make bye-laws for the respective areas under their supervision. Powers similar to those contained in Section 4 of the Infectious Disease (Prevention) Act, 1890, are conferred on district authorities by Section 71 of the Public Health (London) Act, 1891, to stop infected milk-supplies.

In **Scotland,** the provisions of the Dairies, Cow-Sheds, and Milk-Shops Orders of 1885 and 1886 apply as in England, the Local Government Board of Scotland being the central authority, but the provisions with regard to infected milk-supplies are far more stringent.

Section 60 (1) of the Public Health (Scotland) Act, 1897, provides that the medical officer of health shall visit any dairy within his district if he has reason to believe that any person is suffering from infectious disease due to the milk from such dairy, and shall examine the dairy and every person connected with it, and if accompanied by an approved veterinary surgeon, shall also examine the cattle therein, and forthwith report to the local authority or district committee. (2) If he has evidence that any person in the district is suffering from infectious disease attributable to milk from any dairy outside his district, he shall forthwith intimate the same to the local authority of the district in which the dairy is situate, and such authority shall be bound forthwith by its medical officer and veterinary surgeon to inquire, inspect, and report as above. (3) In either case the local authority shall meet forthwith, and if they deem it necessary shall make an order requiring the dairyman not to supply milk until such order is withdrawn. (4) Where proceedings are taken, or an order is made under the section by the local authority of a district other than a burgh, there is no appeal to the County Council. (5) The

local authority in whose district the dairy is situate, may require the dairyman not to supply milk either within or without the district, and shall give notice to the local authority of any district in which they believe milk to be supplied from such dairy. (6) Any such order shall forthwith be withdrawn so soon as the local authority or their medical officer believes that the milk is no longer infected. (7) Any local authority or dairyman aggrieved by any such resolution or order, or withdrawal of order, may appeal to the sheriff in whose district the dairy is situate, and the sheriff may either make an order stopping the milk-supply, or may vary, rescind, or withdraw any order made under the section; but pending the disposal of any such appeal, the order shall remain in force. (8) If any person refuses the medical officer of health or veterinary surgeon of either local authority to make examination as above provided, or, after an order has been made, supplies milk in contravention of such order, he shall be liable to a penalty not exceeding £10, and if the offence continues, to a daily penalty not exceeding £5; (9) provided that (*a*) proceedings be taken before the sheriff having jurisdiction in the place where the dairy is situate, and (*b*) that a dairyman shall not be liable to a breach of contract if the breach be due to an order under this section.

Section 61 of the Act provides further that whenever it shall be certified to the local authority by the medical officer of health or other legally qualified medical practitioner that the outbreak or spread of disease within the district is in the opinion of either attributable to milk supplied by a dairyman, whether wholesale or retail, or to milk supplied by one or other of several such dairymen, then (1) the local authority may require such dairyman to furnish a complete list within a time to be fixed by them, being not less than twenty-four hours, of the names and addresses of all his customers within the district, and the local authority shall pay him for every such list at the rate of 6d. for every twenty-five names, and every person offending against the enactment shall be liable to a penalty not exceeding £5, and a daily penalty not exceeding 40s. (2) The local authority may also require such dairyman to furnish a list of the names and addresses, within a time to be fixed, of all persons from whom, during a period to be specified, the milk, or any part of the milk which they sell or distribute, was obtained, and, if required, to produce to the medical officer, or any person deputed by him, all invoices, pass-books, or other documents connected with the consignment or purchase of milk during such period, and any one offending shall be liable to a penalty not exceeding £5, and a daily penalty not exceeding 40s. (3) If the person liable to any penalty is not resident within the district, such penalty may be sued for at the instance of the procurator-fiscal before the sheriff of the county in which such person resides or carries on his business.

In **Ireland,** an Order in Council was issued in 1879

similar to the English Order which is still in force as amended by the Contagious Diseases (Animals) Act of 1886, and the Local Government Board of Ireland is the central authority.

XXVIII.—Infectious Diseases

1. *General Provisions.*—Section 120 of the Public Health Act, 1875, makes it incumbent on every local authority, on the certificate of the medical officer of health, or of a medical practitioner, to give notice to the owner or occupier for the cleansing or disinfecting of any house or part thereof, or of any articles contained therein, which are likely to retain infection. Failing compliance, a penalty not exceeding 10s. is incurred, and the local authority may themselves cleanse or disinfect, and recover the costs, or they may undertake to do the necessary work, in the first instance, with the consent of the occupier.

(In districts where the Infectious Diseases (Prevention) Act, 1890, has been adopted, the above section is repealed, and Section 5 of the Act affirms that the following provisions shall be in force:— (1) Where the medical officer of health or any other registered practitioner certifies that the cleansing and disinfection of any house or part thereof, and of any articles therein, would tend to prevent infection, the clerk to the local authority shall give written notice to the owner or occupier, that the cleansing and disinfection of such house and articles will be carried out by the local authority, at the cost of such owner and occupier, unless he informs the authority within twenty-four hours from the receipt of the notice, that he will himself cleanse and disinfect to the satisfaction of the medical officer of health within a time fixed in the notice. (2) If he fails to do this within the specified time, the cleansing and disinfection shall be carried out by the officers of the authority under the superintendence of the medical officer of health, and the expenses may be recovered. (3) In the event of the owner or occupier being unable to effectually cleanse and disinfect, the work may be done, with consent, by the local authority. For the purpose of carrying out the provisions of this section, powers of entry between 10 A.M. and 6 P.M. are given by Section 17.)

A local authority is further empowered to destroy infected clothing, bedding, or other infected articles, and to give compensation for the same (Section 121); to provide a disinfecting place with all proper apparatus and appliances, and disinfect free of charge (Section 122); and to provide an ambulance or carriage, and pay for the conveyance of patients to hospital (Section 123). Section 124 provides for the removal of patients to hospitals. Section 125 empowers them to make regulations for removal, and also for detention in hospital.

Section 126 enacts that any person, who, (1) while suffering from dangerous infectious disease, wilfully exposes himself without taking proper precautions, in any street, public place, shop, inn, or public conveyance, or enters any public conveyance without previously notifying to the owner or conductor that he is so suffering; or (2) being in charge of any person so suffering, so exposes such sufferer; or (3) gives, lends, sells, transmits, or exposes, without previous disinfection, any bedding, clothing, rags, or other things which have been exposed to infection, shall be liable to a penalty not exceeding £5, provided that no proceedings shall be taken against persons transmitting with proper precautions any bedding, clothing, or other articles for the purpose of having the same disinfected.

According to Section 127, the owner or driver of any public conveyance, who knowingly conveys a person suffering from dangerous infectious disease, and who does not immediately provide for the disinfection of such conveyance, renders himself liable to a penalty, but no such owner or driver shall be required to convey any person so suffering, unless he has been paid a sum sufficient to cover any loss or expense incurred. Section 128 renders any person liable to a penalty not exceeding £20, who knowingly lets for hire any house, room, or part of a house, in which any person has been suffering from any dangerous infectious disorder, without having the same, and all infected articles, disinfected to the satisfaction of a medical practitioner, and certified in writing by him, and the section applies to any inn-keeper who shall be deemed to let for hire part of a house to any person admitted as a guest into his inn. Section 129 enacts that any person, letting or offering for hire any house or part of a house, who, on being questioned by any person negotiating for the hire of such house, or part of a house, as to the fact of there being, or within six weeks previously having been therein, any person suffering from any dangerous infectious disorder, knowingly makes a false answer to such question, shall be liable to a penalty of £20, or to imprisonment, with or without hard labour, not exceeding one month.

(In districts where the Infectious Diseases (Prevention) Act of 1890 has been adopted, the above provisions have been largely supplemented by the following:—

Section 6 provides that the local authority or their medical officer of health may, by written notice, require (under penalty) any infected clothing or other articles to be delivered to their officer for disinfection. The authority must take away, disinfect, and return such articles free of charge, and, in the event of any unnecessary damage, must compensate the owner.

Section 7 enacts that any person who shall cease to occupy any house or room in which any person has, within six weeks, been suffering from any infectious disease, without having such house or room, and all articles therein liable to retain infection, disinfected to the satisfaction of a registered medical practitioner, as testified by a

certificate signed by him ; or without giving the owner notice of the previous existence of such disease ; or who knowingly makes a false answer when questioned by the owner, or by any person negotiating for the hire of the house or room, as to there having, within six weeks previously, been therein any person suffering from any infectious disease, shall be liable to a penalty not exceeding £10. The local authority must give notice of the provisions of this section to the occupier of any house in which they are aware there is a person suffering from an infectious disease.

Sections 8, 9, and 10 refer to prompt interment (see *ante*, p. 547).

Section 11 provides for the disinfection of any public conveyance otherwise than a hearse, used for the conveyance of an infected body. Any one who hires a conveyance to be so used without giving notice to the owner or driver, or any owner or driver who does not immediately provide for the disinfection of such conveyance after it has been so used, is liable to a penalty.

Section 12 authorises justices of the peace to order the detention in hospital, at the cost of the local authority, of any person suffering from infectious disease who could not be provided with lodging accommodation in which proper precautions could be taken to prevent the spread of the disease by such person. Any order so made must state a specified time, but with full power of renewal if deemed necessary.

Section 13 enacts that any one who knowingly casts or permits to be cast into any ash-pit, ash-tub, or other receptacle for the deposit of refuse matter, any infectious rubbish without previous disinfection, shall be guilty of an offence under the Act.

Under Section 15 the local authority is empowered to provide shelter with attendance for the members of any family in which infectious disease has appeared, who have been compelled to leave their dwellings in order that they may be disinfected by the authority.)

2. *Prevention of Epidemic Disease.*—Section 130 of the 1875 Act empowers the Local Government Board to make, alter, or revoke regulations for the treatment of persons affected with cholera, or any other epidemic or infectious disease, and for preventing the spread of such diseases as well on the seas and rivers of the United Kingdom, and may declare by what authority or authorities such regulations shall be enforced. (See Appendix.)

Section 134 empowers the Local Government Board whenever any part of England appears to be threatened, or is affected by any formidable epidemic, or endemic infectious disease, to make, alter, or revoke regulations, for all or any of the following purposes :—(1) Speedy interment of the dead ; (2) house-to-house visitation ; (3) for the provision of medical aid and accommodation ; for the promotion of cleansing, ventilation, and disinfection, and for guarding against the spread of disease ; and to declare such regulations to be in force within the whole or any parts of the district of a local authority, and to apply to

any vessels, whether in inland waters or arms of the sea, for the period mentioned in such order. All such orders and regulations must be published in the *London Gazette* (Section 135); and local authorities are bound to see that they are properly executed (Section 136); while power of entry on any premises or vessel is given to the local authority or their officers, for the purpose of executing or superintending the execution of any regulations so issued (Section 137). Section 138 provides for the payment of any poor law medical officer or private medical practitioner, who performs any medical service on board any vessel under such regulations; and Section 139 empowers the Local Government Board to combine local authorities for the purpose of the provisions of the Act contained in the above sections, relating to the prevention of epidemic diseases. Section 140 imposes a penalty not exceeding £5 on wilful violation or obstruction.

3. *Notification of Infectious Diseases.* — The Infectious Diseases (Notification) Act, 1889, though still an adoptive Act so far as England and Wales are concerned, has been adopted by more than three-fourths of the sanitary authorities throughout the country, and should certainly be made compulsory. The mode of adoption is by a special resolution of the sanitary authority, which must be duly advertised in a local paper and by handbills, but the Act cannot come into operation until at least one calendar month has elapsed after publication of the resolution (Section 5). The diseases scheduled in the Act are:—*Small-pox, cholera, diphtheria, membranous croup, erysipelas, scarlatina* or *scarlet fever*, and the fevers known as *typhus, typhoid, enteric, relapsing, continued*, or *puerperal*. Sanitary authorities, however, are empowered by special resolution duly advertised as above, to order that the Act shall apply to any dangerous infectious disease other than those mentioned. The order may be for a stated time or permanent, but no such order, or any revocation or variation of it, will be of any validity until approved by the Local Government Board (Sections 6, 7).

Section 3 provides that where an inmate of any building used for human habitation within a district to which the Act extends, is suffering from any infectious disease to which the Act applies, then, unless such building is a hospital in which persons suffering from an infectious disease are received, the following provisions shall have effect:—

(*a*) The head of the family to which such inmate (in the Act referred to as the patient) belongs, and in his default the nearest relatives of the patient present in the building or being in attendance on the patient, and in default of such relatives every person in charge of or in attendance on the patient, and in default of any such person the occupier of the building, shall, as soon as he becomes aware that the patient is suffering from an infectious disease to which the Act applies, send notice thereof to the medical officer of health of the district.

(*b*) Every medical practitioner attending on or called in to visit the patient shall forthwith, on becoming aware that the patient is suffering from an infectious disease to which the Act applies, send to the medical officer of health for the district a certificate stating the name of the patient, the situation of the building, and the infectious disease from which, in the opinion of such medical practitioner, the patient is suffering.

Every person required by this section to give a notice or certificate who fails to give the same, will be liable on summary conviction to a fine not exceeding 40s. If, however, a person is not required to give notice in the first instance, but only in default of some other person, he will not be liable to any fine if he satisfies the court that he had reasonable cause to suppose that the notice had been duly given.

A notice or certificate to be sent to a medical officer of health in pursuance of the above provisions may be sent by being delivered to him, or by being left at his office or residence, or may be sent by post addressed to him at his office or at his residence. Where in any district of a local authority there are two or more medical officers of health of the authority, the certificate must be given to such one of them as has charge of the area in which is the patient referred to in the certificate, or to such other of them as the local authority may from time to time direct.

Section 13 enacts that the provisions of the Act shall apply to every ship, vessel, boat, tent, van, shed, or similar structure used for human habitation, in like manner as nearly as may be as if it were a building, and that a ship, vessel, or boat lying in any river, harbour, or other water not within the district of any local authority within the meaning of the Act shall be deemed, for the purposes of the Act, to be within the district of such local authority as may be fixed by the Local Government Board, and where no local authority has been fixed, then of the local authority of the district which nearest adjoins the place where such ship, vessel, or boat is lying. This section will not, however, apply to any ship, vessel, or boat belonging to any foreign Government, nor will the Act extend to any building, ship, vessel, boat, tent, van, shed, or similar structure belonging to Her Majesty the Queen.

Forms of certificate, prescribed by the Local Government Board, must be issued gratuitously by the sanitary authority to every medical practitioner practising in any district in which the Act is in force, and

a fee of 2s. 6d. is allowed him for each certificate sent by him in accordance with the Act if the case occurs in his private practice, and of 1s. if the case occurs in his practice as medical officer of any public body or institution.

Although it is seen from the above excerpts that the system of notification laid down by the Act is what is called the dual system, in practically carrying out the provisions of the Act, the householder's obligation to notify is, by the tacit agreement of all parties, allowed to lapse, and the only certificate forwarded is that of the medical attendant. If, however, the householder or person in charge of the patient, either through negligence or with a view to concealment, does not call in a medical attendant, and fails to notify, the part of Section 3 applying to him should be enforced by the sanitary authority; or, if the case is not a glaring one, he should be called upon to show reason why he should not be summoned, and this of itself has often a very salutary effect. At the same time, it should be noted that the Act gives no power of entry for the purpose of making inquiries, nor does it give any power for compulsory removal of a patient to a hospital.

As regards combined districts, the Local Government Board has ruled, that the intentions of the Act are fully met if the address or office of the sanitary inspector of any district is made the address or office of the medical officer of health, but in this case the certificate should be addressed to the medical officer of health, *care of* sanitary inspector of such district, and naming both officers. This plan saves delay as regards immediate inquiry, and especially when it becomes necessary to remove a patient to hospital, when recommended or certified fit for removal by the medical attendant. All certificates, however, together with particulars of inquiry and action taken, should be forwarded by the inspector to the medical officer of health without delay, who may then visit or not as circumstances require. All forms of certificate should have the address of the medical officer of health printed on the back.

4. *School Agency in the Spread of Infectious Disease.*—(See

ante, pp. 521-526, and for Memorandum of Local Government Board, see Appendix.)

5. *Infected Milk-Supplies.*—The provisions in the various Acts dealing with infected milk-supplies as applying to the several divisions of the United Kingdom have already been summarised under the heading of "Dairies," etc. (see *ante*, p. 698), and though the powers of making full inquiry are still very restricted except in Scotland, the medical officer of health will, as a rule, have no difficulty in inducing a dairyman not only to stop a suspected supply forthwith, but also to give him a list of his customers, as well as of the persons from whom he may have purchased his milk, by promising the dairyman every assistance for the renewal of his trade when all danger is past, and pointing out to him the risks to his trade and the blame which would attach to him in the event of refusal. In such a juncture, the dread of publicity has often a much greater influence than the fear of a fine.

In **London,** the provisions relating to infectious diseases are all contained in Sections 55-87 of the Public Health (London) Act, 1891, which practically includes the provisions of the Infectious Diseases (Prevention) Act and the Notification Act. In respect of the latter, however, it is made obligatory on the medical officer of health to forward a copy of the notification within twelve hours to the Metropolitan Asylums Managers, and to the head teacher of any school attended by the patient, if a child, or by any child who is an inmate of the same house as the patient. Further, the Asylum Managers are bound to send weekly a complete list of all cases so notified to them to the County Council and to every medical officer of health [Section 55 (4)]. The County Council, as respects London, have the powers of extending the provisions of the Act as to notification to diseases not specifically named in the Act, and the district authorities have similar powers in respect to their districts subject to the approval of the Local Government Board (Section 56).

Under Section 13 of the London County Council (General Powers) Act of 1893, the Local Government Board are em-

powered to transfer any duties and powers to the County Council which they possess under Section 134 of the Public Health Act, 1875, with reference to the prevention of epidemic disease, and in respect to the same they may substitute the County Council for a defaulting local authority. The other provisions as to infectious diseases, disinfection, and preventive measures generally, are similar to those applying to England and Wales.

In **Scotland,** the Infectious Diseases (Notification) Act, 1889, is made compulsory throughout the whole country by Section 44 of the Public Health (Scotland) Act, 1897, and Sections 45-59 of that Act contain provisions as to infectious diseases generally, similar to those contained in the 1875 English Act. But Section 57 is of such importance that it may be fitly quoted *in extenso*, and it applies to such diseases as whooping-cough or measles, as well as the notifiable diseases.

Every parent or person having care or charge of a child who is or has been suffering from infectious disease, or who resides in a house where such disease exists or has existed within a period of three months, who shall knowingly or negligently permit such child to attend school without procuring and producing to the teacher or other person in charge of such school a certificate from the medical officer, which he shall grant free of charge, or from some legally qualified medical practitioner, that such child has become free from disease and infection, and that the house and everything therein exposed to infection has been disinfected to the satisfaction of such medical officer or medical practitioner, shall be liable to a penalty not exceeding forty shillings.

Provided that if a person is not required to send notice in the first instance but only in default of some other person, he shall not be liable to any penalty, if he satisfies the court that he had reasonable cause to suppose that the notice had been duly sent.

Any teacher or person in charge of any school, who shall knowingly permit any child to attend such school in contravention of the provisions of this section, shall be liable to a penalty not exceeding forty shillings.

The stringent provisions in respect to infected milk-supplies have already been summarised under the heading of "Dairies," etc. (see *ante*, p. 699). Sections 78-88 confer similar powers on the Local Government Board of Scotland as regards issuing regulations and orders for the prevention of epidemic diseases, which the English Board possess.

In **Ireland,** the general provisions in respect to the control of infectious diseases are practically identical with those applying to England and Wales, and are contained in Sections 137-148 of the Public Health (Ireland) Act, 1878; while the same powers are conferred on the Irish Local Government Board which the English Board possess as regards the prevention of the spread of infectious disease (Sections 149-156). The Infectious Diseases (Notification) Act, 1889, and the Infectious Disease (Prevention) Act, 1890, are both adoptive Acts, but so far only a few of the authorities have availed themselves of their provisions.

XXIX.—Isolation Hospitals

Section 121 of the Public Health Act, 1875, enacts that "any local authority may provide for the use of the inhabitants of their district hospitals or temporary places for the reception of the sick, and for that purpose may themselves build such hospitals or places of reception; or contract for the use of any such hospital or part of a hospital or place of reception; or enter into any agreement with any person having the management of any hospital, for the reception of the sick inhabitants of their district, on payment of such annual or other sum as may be agreed on. Further, two or more *local* authorities may combine in providing a common hospital."

Section 122 empowers them to provide a disinfecting place, with all proper apparatus and appliances, and disinfect free of charge; while under Section 123 they may provide an ambulance or carriage, and pay for the conveyance of patients to hospital. Where a hospital has been provided, Section 124 enacts that a justice may order the removal of any person suffering from a dangerous infectious disease, on a medical certificate, who is without proper lodging or accommodation, and who is within reasonable distance of such hospital. Further, Section 125 empowers a local authority to make regulations for the removal of patients to hospital, and their retention therein so long as may be necessary, subject to the approval of the Local Government Board. Section 132 enables them to recover the cost of the maintenance of a patient in hospital if not a pauper.

(In places where the Infectious Disease (Prevention) Act, 1890, is in force, patients may be retained in hospital by a justice's order if in an infectious state and without proper accommodation (Section 12), and temporary shelters must be provided for families who may be obliged to leave their dwellings for the purpose of disinfection (see *ante*, p. 703).)

The Isolation Hospitals Act of 1893 was passed to enable county councils to provide, or assist in providing, hospital accommodation in administrative counties. It only applies to England and Wales, and not to London or county boroughs; while other boroughs are exempt except by Order of the Local Government Board if the population at the last census is less than 10,000, or by consent of the corporation, if the population exceeds 10,000 (Section 2).

A *hospital district* under this Act may consist of one or more local areas; a "local area" being defined as including an urban or rural sanitary district, or a contributory place (see *ante*, p. 610), and such a district is constituted by an Order of the County Council, subject to appeal to the Local Government Board on the part of the authorities concerned (Section 8).

As regards mode of procedure, the County Council may take the initiative by directing their medical officer of health to inquire and report concerning the hospital requirements of any part of their county, and by acting on his report; or they may proceed on receiving a petition from any local authority or parish vestry, or from twenty-five ratepayers in any contributory place (Sections 6 and 7). After giving due notice, the County Council must next hold a local inquiry, after which they may either dismiss the petition, if such has been presented, or they may make an Order constituting the hospital district, and defining the area or areas included in the district. But no local area can be included without the consent of its local authority, if in the judgment of the Council it is already provided with sufficient hospital accommodation; nor can a hospital district be formed for one area only, or for one or more local areas within the same rural sanitary district, without the consent of the sanitary authority, unless the County Council are satisfied that the sanitary authority are unable or unwilling to provide suitable accommodation (Section 9). When a hospital district has been constituted, the County Council must form a hospital committee, to consist of representatives of the local area or areas included in the district; but if a grant be made out of the county funds, the committee may consist wholly or in part of county councillors, subject, however, to appeal to the Local Government Board on the part of the sanitary authorities concerned (Section 10). The Order further gives the committee power to acquire land, or by purchase or otherwise to provide and maintain a hospital; and the hospital, if established, must be provided with an ambulance or ambulances, and, so far as practicable, be in connection with a system of telegraphs. Apart from this, the hospital committee are empowered by the Act to make temporary arrangements for isolation, and to establish district hospitals in cottages or small buildings, and, subject to any regulations made by the County Council, they may also undertake the training of

nurses, and may charge for their services outside the hospital (Sections 11-15).

With regard to the expenses incurred in respect of any isolation hospital under the Act, these are classed as "structural," "establishment," or "patients'," expenses;—"structural" to include cost of site, purchase, furnishing, etc., and extensions; "establishment" to include repairs, salaries, and general cost of keeping the hospital in a fit condition to receive patients; and "patients' expenses" to include cost of conveying, feeding, disinfecting, etc. (Section 17). Patients may be charged such sum as the committee may think sufficient to defray the "patients' expenses" incurred, and those desirous of being provided with special accommodation may be charged "special patients' expenses" (Section 16). All expenses incurred other than patients' expenses which may be defrayed, must be paid for out of the rates of such authorities concerned as the Order may determine (Section 18). The expenses of the maintenance of paupers are recoverable from the guardians; and, in respect to other non-paying patients, the expenses are recoverable from the local authority of the area from which the patient is sent (Section 19). Further, a County Council may contribute out of the county rate a capital or annual sum towards the structural and establishment expenses of an isolation hospital under the Act, or to either class of such expenses (Section 21), or they may borrow on the security of the county rate for the purpose of carrying into effect the provisions of the Act, and loans so borrowed will be repaid them, with interest at 4 per cent, out of the local rates (Section 22).

It may be observed in passing that this Act, though of ample scope, has so far not assisted to any marked extent in the provision of hospital accommodation throughout administrative counties generally. This is in great measure due to the supineness of the majority of County Councils, and to the opposition which they have sometimes to face on the part of local authorities when they do resolve to take action. The only fair way would be to purchase existing hospitals by taking up the unexpired debts on them, constitute hospital districts, and build additional hospitals where necessary. Much opposition, too, would be allayed on the part of rural authorities if the Act were so amended as to permit of the formation of contributory areas, or of differential rating, because for scattered outlying parishes in a rural district, which very often surround a large urban district, the need of hospital accommodation is not nearly so pressing as for the larger villages in the neighbourhood of

the central or Union town. As the law at present stands, a rural district which contains no contributory place as such, if it is included in a hospital district, must form a local area as a whole, and County Councils have no power to schedule parishes for differential rating, or include some and exclude others from any hospital district which they may constitute.

Another great obstacle to the provision of isolation hospitals is the rule laid down by the Local Government Board that no small-pox hospital should be erected within a quarter of a mile of a hospital intended for the reception of other cases of infectious disease, which practically means two separate sites for every hospital district (see *ante*, p. 406).

With regard to the provisions as to charging for the maintenance of patients, it is agreed on all sides that it is not a wise policy to enforce such payment unless the patient is treated in a separate ward as a paying patient.

In **London,** the whole of the metropolis constitutes one asylum district under the management of the Asylum Board of Managers, who are empowered by the Metropolitan Poor Acts of 1867 and 1871, and the Diseases Prevention (Metropolis) Act of 1883, to provide asylums for the insane, as well as isolation hospitals.

In **Scotland,** Section 66 of the Public Health (Scotland) Act, 1897, not only invests local authorities with powers similar to those contained in the English Act of 1875 for the provision of hospital accommodation for their districts, either singly or by combination, but makes it obligatory on them to do so if required by the Local Government Board. A local authority may also provide one or more portable hospitals for the use of their district, and Section 67 gives power to provide, either singly or by combination, ambulances for the removal of patients.

In **Ireland,** the general provisions as to the erection and maintenance of hospitals, as set forth in Sections 155 and 156 of the Public Health (Ireland) Act, 1878, are similar to those contained in the English Act of 1875, but the Isolation Hospitals Act does not apply.

XXX.—Mortuaries and Cemeteries

Most of the legislative enactments and regulations relating to these have already been summarised in the Chapter on Disposal of the Dead—for example as to the provision of mortuaries and post-mortem rooms by sanitary authorities, and the removal of dead bodies (see *ante*, p. 546); the construction and laying out of cemeteries (p. 548); the closing of burial-grounds (p. 549); the powers vested in sanitary authorities to provide cemeteries, and the Memorandum of the Local Government Board relating thereto (p. 550); and the Home Office Rules to prevent overcrowding in cemeteries, and ensure deodorisation and natural decomposition (p. 559).

In **London,** Section 88 of the Public Health (London) Act, 1891, renders it obligatory on sanitary authorities to provide mortuaries, and Section 89 empowers a justice to order the removal of dead bodies in cases similar to those provided in the Infectious Diseases (Prevention) Act, 1890. Section 90 empowers them to provide post-mortem rooms, and the County Council may require them to do so; while Section 91 gives power to combine for these purposes. By Section 92 the duty is imposed on the County Council of providing accommodation for the holding of inquests, and Section 91 empowers them to provide public mortuaries subject to regulations as to their use by the Secretary of State. The general enactments as to cemeteries are the same in London as in the provinces.

In **Scotland,** the powers relating to provision of mortuaries and post-mortem rooms by local authorities, and the removal of dead bodies, are set forth in Sections 68-71 of the Public Health (Scotland) Act, 1897. Although no power is given to local authorities to provide burial-grounds they can deal with overcrowded burial-grounds as statutory nuisances (see *ante*, p. 637), and parish councils carry out the provisions of the Burial-Ground Act, 1885.

In **Ireland,** Section 157 of the Public Health (Ireland) Act confers similar powers on sanitary authorities as to the

provision of mortuaries, etc., as are conferred by the English Act of 1875. Section 162 of the same Act empowers the Local Government Board on representation made to them to close old, or prohibit the opening of new, burial-grounds. Section 160 constitutes sanitary authorities the burial-boards of their districts, except in towns having commissioners under local Acts, where the poor-law guardians become the burial-boards. Whenever a burial-ground has been closed by order of the Local Government Board, the burial-boards are vested by Sections 172-234 with full powers to provide burial-grounds subject to the regulations of the Local Government Board.

XXXI.—Bye-Laws and Regulations

In a circular first issued by the Local Government Board in 1877, for the guidance of local authorities in framing bye-laws, under the Public Health and other Sanitary Acts, they point out that, in accordance with Section 182 of the 1875 Act, a bye-law to be in harmony with the laws of England must be certain and determinate, and likewise reasonable. It will also be invalid if it be repugnant to the provisions of the Act under which it has been framed. Parliament has distinctly specified a variety of purposes for which bye-laws may be made, and for these purposes alone are they authorised. Sanitary authorities cannot legally assume the power of making bye-laws for the carrying out the general objects of any Act which empowers them to make bye-laws. It follows, therefore, that every bye-law must be strictly limited with reference to the terms of the specific enactment from which its force is derived. Moreover, it should always be remembered that bye-laws, to have the force of law, are designed to supplement, and not to vary or supersede, the express provisions of the statute law, though it is quite open to a sanitary authority to append a summary of the requirements of the statute bearing upon the same matters.

All bye-laws to have effect must be duly advertised, and they must be submitted to, and receive the approval of, the Local Government Board. When approved they must be printed and hung up in the office of the sanitary authority, and any ratepayer who applies is entitled to receive a copy (Sections 182-185 of the 1875 Act).

Every sanitary authority desirous of making new bye-laws or of amending existing bye-laws will, on application, be supplied by the Board with draft forms. These forms contain the whole of the clauses comprised in the model series, with an ample margin for annotations. As a rule, sanitary authorities are inclined to regard many of these clauses as of too stringent a character, and, though modifications are allowed, the Board expressly state that all bye-laws are open to objection, which, while purporting to lay down rules enforceable by penalties, ignore the necessary details, and substitute vague conditions which render compliance with the bye-laws dependent upon the approval, by the sanitary authority or their officers, of the mode of proceeding in each case.

Under Section 183 of the Public Health Act, 1875, authorities are empowered in framing any bye-laws to impose reasonable penalties not exceeding £5 for each offence, or £2 : 2s. for each day in the case of a continuing offence, but the Board advise that all such bye-laws should be so framed as to allow the recovery of any sum less than the full amount of the penalty.

Regulations differ somewhat from bye-laws because with few exceptions, such as those expressly stipulated by enactments, they do not require confirmation by the Local Government Board. Any urban authority, for example, may make regulations with respect to the duties and conduct of officers or servants without the approval of the Board.

In some few instances, the framing of bye-laws is compulsory, as, for example, in respect to common lodging-houses by all authorities, and slaughter-houses by urban authorities. Some bye-laws may be made by both urban

and rural authorities, while there are others which urban authorities are alone empowered to make.

The more important Model Bye-Laws issued by the Local Government Board have already been quoted or summarised under various headings in this chapter or in previous portions of the work, and the following brief catalogue is only intended for reference :—

1. *Urban* sanitary authorities are empowered to make bye-laws as under :—

(1) Private scavenging (see *ante*, p. 618).
(2) Prevention of nuisances (p. 618).
(3) Common lodging-houses (p. 658).
(4) Houses let in lodgings (p. 659).
(5) New streets and buildings (pp. 676-680).
(6) Tents and vans (p. 661).
(7) Hop-pickers' and fruit-pickers' lodgings (p. 662).
(8) Slaughter-houses (p. 652).
(9) Offensive trades (p. 640).
(10) Baths and wash-houses (p. 685).
(11) Market and Fairs (p. 651).
(12) Open spaces and pleasure grounds (p. 683).
(13) Cemeteries (p. 550).
(14) Mortuaries (p. 712).
(15) Public conveniences (p. 615).
(16) Other bye-laws.

Urban authorities are also authorised to make bye-laws in respect to hackney carriages, pleasure boats, etc.

2. *Rural* authorities have the same powers as urban authorities to make bye-laws in respect to the following, under the enactments already quoted :—

(1) Private scavenging.
(2) Common lodging-houses.
(3) Houses let in lodgings.
(4) Seamen's lodgings.
(5) Tents and vans.
(6) Hop-pickers'.
(7) Fruit-pickers'.
(8) Cemeteries.
(9) Mortuaries.

As previously pointed out, the Local Government Board, under Section 276 of the 1875 Act (p. 608), may confer upon them any other powers as to the framing of bye-laws which the Public Health Acts confer on urban authorities, while, by adopting Part III. of the Public Health Acts (Amendment) Act, 1890, they can make certain bye-laws in

respect to old as well as new buildings, closets, and drainage. The framing of bye-laws in respect to common lodging-houses is compulsory, if any exist in a rural district, but for all other purposes it is optional. Indeed, it may be said that the great majority of rural authorities throughout England and Wales have neither applied for urban powers, nor have they any bye-laws which they are authorised to make without such powers.

Model bye-laws as enumerated above have been prepared by the Local Government for the guidance of sanitary authorities.

As regards regulations, every sanitary authority is empowered to make regulations under the Cow-sheds and Dairies Order, 1885, for purposes which have already been quoted (p. 695). Section 125 of the 1875 Act also empowers them to make regulations for the removal to, and detention in, hospital, as long as may be deemed necessary, of persons brought within their district by ship or boat suffering from dangerous infectious disease (p. 701), and Section 143 of the same Act empowers them to make regulations for the management of post-mortem rooms.

In **London,** the County Council, under the London Building Act, 1894, and Local Management Acts, have power to make bye-laws for the regulation of new streets and buildings, and of drains and sewers. Under the Public Health (London) Act, 1891, they *must* make bye-laws for regulating offensive trades and the structure of premises (Section 19); as to water-closets and sanitary fittings (Section 39); for prescribing the times for removal of offensive refuse and the precautions to be taken to prevent nuisance, and for the closing of cess-pools, etc.; and for the removal of house refuse (Section 16).

The 1891 Act also renders it obligatory on metropolitan sanitary authorities to make bye-laws in respect to scavenging and the prevention of nuisance; the keeping of animals; the paving of yards and open spaces in connection with dwellings (Section 16); the keeping of water-closets sufficiently flushed (Section 39); and the cleansing and protecting

of all cisterns, etc., used for storing water for domestic use, or for the manufacture of beverages (Section 50).

Metropolitan sanitary authorities *may* make bye-laws in relation to tenement houses, tents, vans, etc. (Section 95); and removal to hospital of infectious cases, and retention therein (Section 66). Further, they *must* enforce any bye-laws made by the County Council under Sections 16 and 39 of the Public Health (London) Act as above.

In the City, the Commissioners of Sewers have powers to make similar bye-laws, and both the County Council and the Corporation have power to make bye-laws under the Dairies, Cow-sheds, and Milk-shops Order, 1885.

In **Scotland,** local authorities are empowered under the Public Health (Scotland) Act, 1897, to make bye-laws in respect to offensive trades, including slaughter-houses (Section 32); pig-styes (Section 35); public conveyances (Section 65); tenement houses (Section 72); common lodging-houses (Section 92), and buildings (Section 181), (see p. 681). The Local Government Board have issued model bye-laws in respect to common lodging-houses, tenements or houses let in lodgings, and slaughter-houses.

In **Ireland,** the provisions as to making bye-laws under the Public Health (Ireland) Act, 1878, and the bye-laws themselves, are similar to those applying to England and Wales, though not so comprehensive.

XXXII.—Legal Proceedings

Only a few selected sections under this heading may be summarised, because in deciding to take legal proceedings sanitary authorities should always be advised by their clerks, who should also conduct the cases in court, either personally, or by deputy.

Section 251 of the Public Health Act, 1875, enacts that all offences under this Act, and all penalties, forfeitures, costs, and expenses under this Act directed to be recovered in a summary manner, or the recovery of which is not otherwise provided for, may be prosecuted and recovered before a court of summary jurisdiction, constituted of two or more justices of the peace in petty sessions,

or of some stipendiary magistrate. Section 252 provides that any complaint or information made or laid in pursuance of this Act shall be made or laid within six months from the time when the matter of such complaint or information respectively arose. Where any nuisance under this Act appears to be wholly or partially caused by the acts or defaults of two or more persons, Section 255 renders it lawful for the local authority or other complainant to institute proceedings against any one of such persons, or to include all or any two ; and whenever such proceedings are taken relating to nuisances, it will be sufficient to designate the "owner" or "occupier" of the premises concerned without name or further description. Section 259 empowers any local authority to appear before any court, or in any legal proceedings by their clerk, or by *any officer or member authorised generally or in respect of any special proceeding by resolution of such authority*, and their clerk, or any officer or member so authorised, shall be at liberty to institute and carry on any proceeding which the local authority is authorised to institute and carry on under this Act. Section 265 affords protection of local authority and their officers from personal liability when acting under the direction of such authority, except legal surcharges imposed by the public auditor. According to Section 266, notices, orders, and other such documents under this Act may be in writing or print, or partly in both ; and Section 267 provides that such notices and orders required or authorised to be served under this Act may be served by delivering the same to or at the residence of the person to whom they are respectively addressed, or where addressed to the *owner or occupier* of premises by delivering the same, or a true copy thereof, to some person on the premises, or if there is no such person on the premises who can be served, by fixing the same on some conspicuous part of the premises. They may also be served by post by a prepaid letter, and simply addressed by the description of the "owner" or "occupier" of the premises (naming them) in respect of which the notice is given, without further name or description. Further, Section 268 authorises appeal to the Local Government Board, where any person feels aggrieved at the decision of a local authority to recover in a summary manner any expenses incurred by them, or to declare such expenses to be private improvement expenses, provided the Board are memorialised within twenty-one days after notice of such decision, and a copy of the memorial is delivered to the local authority. The order of the Local Government Board in respect to such matter shall be final, and proceedings if commenced must be stayed.

Similar methods of legal procedure, apart from differences as to courts of local jurisdiction, are contained in the Public Health Acts for London, Scotland, and Ireland.

XXXIII.—Port Sanitary Authorities

A port, which is much frequented by shipping, very often extends along the districts of more than one riparian authority, so that vessels before entering a harbour generally pass from the jurisdiction of one or more authorities into that of another authority. Hence the desirability of placing the shipping of such ports under the control of one authority, which is called the Port Sanitary Authority.

Every port sanitary authority now in existence has been constituted either by Order, or by Provisional Order, of the Local Government Board under the Public Health Act, 1872, the Public Health Act, 1875, or the Public Health (Ships) Act, 1885.

Section 287 of the 1875 Act empowers the Local Government Board to constitute by provisional order any local authority, whose district abuts on any part of a port in England, the authority for the whole or any part of such port. The Board may also combine two or more riparian authorities to constitute a port sanitary authority, or may constitute one port authority for two or more ports, and such authority may be constituted permanently or temporarily by provisional order. Further, any order constituting a port sanitary authority may assign to such authority any powers, rights, duties, capacities, liabilities, and obligations under this Act possessed by a local authority, so far as these are applicable to ships, vessels, boats, waters, or persons, viz. as regards nuisances under Sections 91-111; infectious diseases and hospitals, Sections 120-133 (under Section 2 of the Public Health (Ships) Act); power of local authority to enter vessels, Section 137; prevention of epidemic disease, Section 134; mortuaries, Sections 141, 142; bye-laws, Sections 182-186; appointment of officers, Section 189; and powers to purchase land, etc., Sections 175-177.

The regulations now in force under Section 130 of the Public Health Act, 1875, were issued in 1896, and apply to cholera, yellow fever, and plague (see Appendix). (Under Section 1 of the Public Health Act, 1896, it is provided that these regulations may be enforced and executed by the officers of customs and coastguard men, as well as by the officers of port sanitary authorities.)

In **London,** the City Corporation were created the port sanitary authority by the Public Health Act, 1872, and since reaffirmed by Section 11 of the Public Health (London) Act, 1891, and as such are vested with all the powers, duties,

and obligations which are conferred on other port sanitary authorities.

In **Scotland,** Sections 172-176 of the Public Health (Scotland) Act, 1897, confers powers on the Local Government Board similar to those vested in the English Board to constitute port sanitary authorities and assign to them any powers, rights, duties, etc., under the Act as are possessed by a local authority; whilst Sections 78-88 empower the Board to issue regulations as far as possible identical with those issued by the English Board under Section 130 of the 1875 Act. (See Appendix.)

In **Ireland,** there are no port sanitary authorities as they exist in England; but the Irish Local Government Board under Section 148 of the Public Health (Ireland) Act, 1878, have power to issue regulations similar to those issued by the English Board.

XXXIV.—Powers of the Local Government Board

Apart from the powers of the Board to issue Orders, Regulations, and confirm bye-laws, and their general control over borrowing money on loan, they have extensive powers under Section 293 of the Public Health Act, 1875, to cause to be made such inquiries as are directed by the Act, and such inquiries as they see fit in relation to any matters concerning the public health in any place, or any matters with respect to which their sanction, approval, or consent is required by the Act, and for the purposes of any such inquiry, the Inspectors of the Board have power, under Section 296, to take evidence on oath or attested by signature, to order the production of any papers and accounts, and to inspect places or matters required to be inspected.

Section 299 is a very important one, because it sets forth in detail the power of the Local Government Board to enforce performance of duty on defaulting local authorities. This section is therefore given in full:—

Where complaint is made to the Local Government Board that a local authority has made default in providing their district with

sufficient sewers, or in the maintenance of existing sewers, or in providing their district with a supply of water, in cases where danger arises to the health of the inhabitants from the insufficiency or unwholesomeness of the existing supply of water, and a proper supply can be got at a reasonable cost, or that a local authority has made default in enforcing any provisions of this Act which it is their duty to enforce, the Local Government Board, if satisfied, after due inquiry, that the authority has been guilty of the alleged default, shall make an order limiting a time for the performance of their duty in the matter of such complaint. If such duty is not performed by the time limited in the order, such order may be enforced by writ of mandamus, or the Local Government Board may appoint some person to perform such duty, and shall by order direct that the expenses of performing the same, together with a reasonable remuneration to the person appointed for superintending such performance, and amounting to a sum specified in the order, together with the costs of the proceedings, shall be paid by the authority in default; and any order made for the payment of such expenses and costs may be removed into the Court of Queen's Bench, and be enforced in the same manner as if the same were an order of such court.

Any person appointed under this section to perform the duty of a defaulting local authority shall, in the performance and for the purposes of such duty, be invested with all the powers of such authority other than (save as hereinafter provided) the powers of levying rates; and the Local Government Board may from time to time by order change any person so appointed.

It may be remarked here that any person, according to this section, may make written complaint to the Local Government Board, not only in respect to insufficient sewerage or water-supply, but in respect to any neglect on the part of a local authority in enforcing any of the provisions of this Act which it is their duty to enforce, and, as shown under various previous headings, this last includes a wide range of sufficient grounds for complaint. Section 106 of the 1875 Act is of special importance, because it empowers the Local Government Board to take action in respect to neglected nuisances (see *ante*, p. 635).

Similar powers are conferred on the Local Government Boards of Scotland and Ireland, though not of such a varied and extensive character. In Scotland, the sheriff has power to intervene on default in respect to nuisances, and the Local Government Board, with the approval of the Lord Advocate,

may also institute proceedings to compel defaulting authorities to do their duty.

XXXV.—Sanitary Powers of County Councils

The sanitary powers vested in County Councils throughout England and Wales are comparatively few, and may be summarised as follows:—

Section 14 of the Local Government Act, 1888, confers upon them all the powers of a sanitary authority under the Rivers Pollution Act (see *ante*, p. 621), and enables the Local Government Board to form a joint-committee representing all the administrative counties through which a river, or any specified portion of a river, or any tributary thereof passes, and to vest in the joint-committee all or any of the powers of a sanitary authority under the Act.

Section 17 of the same Act empowers a County Council to appoint one or more medical officers of health for a county, and Section 19 enacts that copies of all periodical reports which have to be forwarded to the Local Government Board must be transmitted to them by the medical officers of districts, or parts of districts, situated in the county. If it appears to a County Council from any such report that the provisions of the Public Health Act, 1875, have not been properly put in force within the district to which the report relates, or that any matter affecting the health of the district requires to be remedied, Section 19 further authorises the council to cause a representation to be made to the Local Government Board on the matter. Section 16 empowers them, subject to the approval of the Local Government Board, to make bye-laws in relation to the whole or any specified part of a county, boroughs excepted, for several purposes including the suppression of nuisances, not already punishable in a summary manner by any Act in force throughout the county, in other words, they have no power to deal with any nuisances which come under the control of sanitary authorities as such.

Section 57 enables them to take action with reference to the alteration of the boundaries of sanitary districts other than boroughs, but any orders which they may see fit to issue in these respects, and as to the formation of new urban or rural districts, must be confirmed by the Local Government Board (see *ante*, p. 610).

Further powers are conferred on them by the Local Government Act, 1894.

Under Section 16 of that Act the County Council, on complaint of a parish council that there has been default on the part of the sanitary authority in respect to the sewerage or water-supply

of a district, whether urban or rural, may after due inquiry order that the duties and powers of such authority be transferred to themselves, or make such an order as the Local Government Board may make under Section 299 of the 1875 Act (p. 721). Section 25 of the 1894 Act also authorises them to apply to the Local Government Board to grant urban powers for rural districts.

Under the Housing of the Working Classes Act, 1890, powers are conferred on them in respect to unhealthy dwellings when the sanitary authority is in default, and Part III. of that Act can only be adopted by rural authorities on a certificate of a County Council (see *ante*, p. 672).

The powers and duties of County Councils under the Isolation Hospitals Act, 1893, have already been fully summarised (p. 709).

In **London,** the County Council are vested with much more extensive powers than are the councils of administrative counties. They have the sole control of the main sewers of London and the disposal of sewerage (p. 614); and they have certain important powers of control in respect to water-supply (p. 626), new streets and buildings (p. 680), offensive trades (p. 642), slaughter-houses (p. 654), the carrying out of the Dairies, Cow-sheds, and Milk-shops Order (p. 699), the cleansing of streets and prevention of particular nuisances (p. 620), tenement houses, etc. They are entrusted with the execution of the Housing of the Working Classes Act, 1890 (p. 666), and under Section 100 of the Public Health (London) Act, 1891, they have power to prosecute on default of any sanitary authority in doing their duty under this Act with respect to the removal of any nuisance, the institution of any proceedings, or the enforcement of any bye-law.

In **Scotland,** County Councils must appoint sanitary officers, and along with their district committees, as local authorities, carry out all the duties and obligations devolving upon such authorities under the Public Health (Scotland) Act, 1897, the Rivers Pollution Acts, the Housing of the Working Classes Acts, Factory and Workshops Acts, Dairies, Cow-sheds, and Milk-shops Orders, Food Adulteration Acts, etc.

In **Ireland,** County Councils, as such, have not yet been constituted.

XXXVI.—Sanitary Powers of Parish Councils and Parish Meetings

Under the Local Government Act, 1894, the Parish Meeting has the exclusive power (Section 7) of adopting certain optional Acts, including the Burials Acts, 1852 to 1885, and the Baths and Wash-Houses Acts, 1846 to 1882 (see *ante*, p. 685). The Parish Council have power (Section 8) to provide water-supplies under certain conditions (p. 626), and to clean out any foul ditch, pond, etc., and execute certain limited works of drainage (p. 632).

Under Section 16 they may complain to the County Council of default on the part of the sanitary authority, and the County Council may take action. They may acquire or hire lands for allotments (Sections 9 and 10). They may also make official representation to the medical officer of health as to unhealthy or obstructive dwellings or apply to the Local Government Board for urban powers. The district council may delegate to them any powers which may be delegated to a parochial committee under the Public Health Act, 1875 (p. 608). Apart from expenditure under adoptive Acts, a Parish Council must not incur any expenses involving more than a 6d. rate in any year, nor more than a 3d. rate without the consent of the Parish Meeting; nor can they incur any expenditure involving a loan without the consent of the County Council (Section 11). They may, however, borrow on loan subject to the consent of the County Council and the Local Government Board (Section 12).

In **London,** there are no Parish Councils as such. In **Scotland,** Parish Councils have taken the place of the old parochial boards under the provisions of the Local Government Bill of 1894, but beyond administering the provisions of the Burial-Grounds (Scotland) Act of 1855 they have no special sanitary functions.

In **Ireland,** no parish councils have been as yet constituted.

CHAPTER XX

SANITARY OFFICERS AND THEIR DUTIES

By Section 189 of the Public Health Act, 1875, it is enacted that, in addition to a clerk and treasurer, it shall be the duty of every urban authority to appoint fit and proper persons to be medical officer of health, surveyor, and inspector of nuisances; while Section 190 makes it the duty of every rural authority to appoint a medical officer of health and inspector of nuisances, and such other officers as may be necessary for the efficient execution of the Act. Although a rural authority, therefore, is not required to appoint a surveyor, this section gives power to appoint, and in respect to both urban and rural authorities, Section 192 provides that the same person may be both surveyor and inspector of nuisances—an arrangement which is often adopted by small urban or rural authorities, when the latter have obtained urban powers.

Section 191 also provides that two or more authorities, whether urban or rural, may appoint the same medical officer of health or inspector of nuisances, and it further authorises any medical officer of health to exercise any of the powers with which an inspector of nuisances is invested by the Act. The same section likewise enacts that if any portion of the salary of a medical officer of health or inspector of nuisances is paid out of moneys voted by Parliament, the Local Government Board possesses the same powers with regard to appointment, salary, and tenure of office as it exercises in the case of poor-law officers. In respect to the office of surveyor there is no repayment of

portion of salary, so that unfortunately he is not a protected officer in the same sense as the medical officer of health or inspector of nuisances, half of whose salaries is now repaid by county councils to their sanitary authorities under the provisions of the Local Government Act, 1888. Although a sanitary authority can suspend an officer appointed under these conditions, it cannot dismiss him without the sanction of the Local Government Board, and it must forthwith report any suspension to the Board. If, however, a sanitary authority desires to make any change in the duties or salary of an officer, or any alteration is made in the area of the district, and he declines to acquiesce therein, they can, but only with the consent of the Local Government Board, give him six months' notice to terminate his appointment. But even this degree of protection is qualified to a very serious extent by the short terms for which the great majority of medical officers of health and inspectors of nuisances throughout England and Wales continue to be appointed. Moreover, when no part of the salary is repayable, approval by the Local Government Board is not required, and the authority may fix the salary at as low a sum as they please. In common with other sanitary officials, medical officers of health, surveyors, and inspectors of nuisances are prohibited, by Section 193 of the 1875 Act, from being concerned in contracts with the sanitary authority, and under the Public Bodies Corrupt Practices Act, 1889, very severe penalties are imposed on "every person who solicits, receives, or agrees to receive corruptly any gift, fee, loan, or reward on account of any member, officer, or servant of any public body doing or forbearing to do anything in respect of any matter or transaction in which such public body is concerned."

Section I.—Medical Officers of Health

Apart from the provision already referred to that two or more sanitary authorities may appoint the same medical officer of health, Section 286 of the Public Health Act,

1875, empowers the Local Government, on sufficient representation made to them, to combine districts by compulsory order for the appointment of a medical officer of health, who is, by the terms of his appointment, debarred from general practice; but only a few such appointments have been made. Section 17 of the Local Government Act, 1888, authorises county councils to appoint medical officers of health, who may be prohibited from engaging in private practice, or from holding any other appointment; but by mutual agreement such officers may be appointed sole medical officers of health of districts within the county.

In respect to qualifications, Section 18 of the Local Government Act, 1888, requires that, except where the Local Government Board for reasons brought to their notice may see fit to allow, every medical officer of health appointed after the 1st of January 1892 for any county, district, or for any combination of districts, must not only be legally qualified for the practice of medicine, surgery, and midwifery, but if appointed to a county or district having at the last census 50,000 inhabitants or more, must also be the registered holder of a diploma in Public Health, under Section 21 of the Medical Act, 1886, or must have been during some three consecutive years prior to 1892 medical officer of health of a district containing at least 20,000 inhabitants at the last census; or have been for not less than three years a medical officer or inspector of the Local Government Board.

Every medical officer of health, who holds his appointment subject to the approval of the Local Government Board, is bound, by order of the Board, to forward copies of annual and special reports to the Board, and also to the county council or councils in which his district is situated, and in the event of his failing to do so, the sanitary authority may be refused repayment of half his salary, and the sum, on the certificate of the Local Government Board, shall be forfeited to the Crown. If no part of his salary is intended to be payable by a county council, his duties are nevertheless the same as those prescribed for all health officers appointed with the approval of the Local Government Board, and he

is further obliged to report his appointment within seven days to the Board.

In **London,** the qualifications of a medical officer of health are similar to those required in the provinces, and the Local Government Board exercise the same powers with regard to appointment, salary, duties, and tenure of office. But Section 108 of the Local Government (London) Act, 1891, secures permanency of tenure by providing that "(1) a medical officer will be removable by the sanitary authority with the consent of the Local Government Board, or by that Board, and not otherwise; and (2) any such officer must not be appointed for a limited period only."

Under Section 106 of the same Act, every sanitary authority in London is required to appoint one or more medical officers of health for its district; and the same person may, with the sanction of the Local Government Board, be appointed medical officer of health for two or more districts; but except in cases specially allowed by the Board, every such person must reside in that district, or within one mile outside its boundary. As in the provinces, a medical officer of health may exercise any of the powers with which a sanitary inspector is invested, and his annual report to the sanitary authority must be affixed to the annual report of that authority.

In **Scotland,** a medical officer must be a registered medical practitioner, and cannot be appointed for a county, district, or parish with a population of 30,000 or upwards unless he holds a diploma in Public Health. Every county council must appoint one or more medical officers, who shall not hold any other appointment, or engage in private practice without the written consent of the council, and such officer or officers may be and usually are reappointed by the district committees as district officers—every district committee being empowered to appoint one or more medical officers for their district who is generally the county medical officer. In addition to these appointments, the commissioners of every burgh must appoint a medical officer of health who must be a registered medical practitioner, and if appointed after May 1894, must also hold a diploma in

Public Health. No medical officer, whether for county, district, or burgh, can be removed from office without the consent of the Local Government Board for Scotland.

In **Ireland,** according to Section 11 of the Public Health (Ireland) Act, 1878, the dispensary medical officers are *ex officio* medical officers of health for their respective districts, but in addition to these the Irish Local Government Board by their orders may require every rural sanitary authority, when directed by them, to appoint a consulting sanitary officer or a medical superintendent officer of health, and for either of these appointments the medical officer of the Union Workhouse, or any duly qualified medical practitioner, is eligible. Urban sanitary authorities when directed by the Local Government Board must also appoint a consulting sanitary officer, medical superintendent of health, or executive sanitary officer, but in Ireland no officer charged with the administration of public health is restricted from private practice, and the salaries, as a rule, are miserably inadequate, though a part is repaid by the Treasury. Tenure of office, however, is secured to the extent that no officer can be removed during the period of his appointment without the assent of the Local Government Board.

In England, Scotland, and Ireland, the duties devolving upon medical officers of health are regulated by orders of the respective Local Government Boards, but as they all conform in respect to principal details, it will suffice to quote those issued by the Local Government Board of England in respect to all medical officers of health, whether of urban or rural districts, and to medical officers of health of port sanitary authorities. For county medical officers of health in England and Wales there are no officially prescribed duties beyond those attaching to the limited sanitary functions of county councils, and only a few such officers have been appointed.

In the Board's Order of March 1891, the following are the duties prescribed for every medical officer of health in respect to his district or districts, and they apply whether part of his salary is returned or not:—

1. He shall inform himself, as far as practicable, respecting all influences affecting or threatening to affect injuriously the public health within the district.

2. He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation.

3. He shall, by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed of the conditions injurious to health existing therein.

4. He shall be prepared to advise the sanitary authority on all matters affecting the health of the district, and on all sanitary points involved in the action of the sanitary authority ; and in cases requiring it, he shall certify, for the guidance of the sanitary authority or of the justices, as to any matter in respect of which the certificate of a medical officer of health or a medical practitioner is required as the basis or in aid of sanitary action.

5. He shall advise the sanitary authority on any question relating to health involved in the framing and subsequent working of such bye-laws and regulations as they may have power to make, and as to the adoption by the sanitary authority of the Infectious Disease (Prevention) Act, 1890, or of any section or sections of such Act.

6. On receiving information of the outbreak of any contagious, infectious, or epidemic disease of a dangerous character within the district, he shall visit without delay the spot where the outbreak has occurred, and inquire into the causes and circumstances of such outbreak, and in case he is not satisfied that all due precautions are being taken, he shall advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and take such measures for the prevention of disease as he is legally authorised to take under any statute in force in the district, or by any resolution of the sanitary authority.

7. Subject to the instructions of the sanitary authority, he shall direct or superintend the work of the inspector of nuisances in the way and to the extent that the sanitary authority shall approve, and on receiving information from the inspector of nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall, as early as practicable, take such steps as he is legally authorised to take under any statute in force in the district, or by any resolution of the sanitary authority, as the circumstances of the case may justify and require.

8. In any case in which it may appear to him to be necessary or advisable, or in which he shall be so directed by the sanitary authority, he shall himself inspect and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, or milk, and any other article to which the provisions of the Public Health

Act, 1875, in this behalf shall apply, exposed for sale, or deposited for the purpose of sale or of preparation for sale, and intended for the food of man, which is deemed to be diseased, or unsound, or unwholesome, or unfit for the food of man ; and if he finds that such animal or article is diseased, or unsound, or unwholesome, or unfit for the food of man, he shall give such directions as may be necessary for causing the same to be dealt with by a justice according to the provisions of the statutes applicable to the case.

9. He shall perform all the duties imposed upon him by any bye-laws and regulations of the sanitary authority, duly confirmed where confirmation is legally required, in respect of any matter affecting the public health, and touching which they are authorised to frame bye-laws and regulations.

10. He shall inquire into any offensive process of trade carried on within the district, and report on the appropriate means for the prevention of any nuisance or injury to health therefrom.

11. He shall attend at the office of the sanitary authority or at some other appointed place, at such stated times as they may direct.

12. He shall from time to time report, in writing, to the sanitary authority his proceedings, and the measures which may require to be adopted for the improvement or protection of the public health in the district. He shall in like manner report with respect to the sickness and mortality within the district, so far as he has been enabled to ascertain the same.

13. He shall keep a book or books, to be provided by the sanitary authority, in which he shall make an entry of his visits, and notes of his observations and instructions thereon, and also the date and nature of applications made to him, the date and result of the action taken thereon, and of any action taken on previous reports ; and shall produce such book or books, whenever required, to the sanitary authority.

14. He shall also make an annual report to the sanitary authority, up to the end of December in each year, comprising a summary of the action taken, or which he has advised the sanitary authority to take, during the year for preventing the spread of disease, and an account of the sanitary state of his district generally at the end of the year. The report shall also contain an account of the inquiries which he has made as to conditions injurious to health existing in the district, and of the proceedings in which he has taken part or advised under any statute, so far as such proceedings relate to those conditions ; and also an account of the supervision exercised by him, or on his advice, for sanitary purposes over places and houses that the sanitary authority have power to regulate, with the nature and results of any proceedings which may have been so required and taken in respect of the same during the year. The report shall also record the action taken by him, or on his advice, during the year, in regard to offensive trades, to dairies, cow-sheds, and milk-shops, and to factories and workshops. The report shall also contain tabular statements (on Forms to be

supplied by Us, or to the like effect) of the sickness and mortality within the district, classified according to diseases, ages, and localities.

Provided that, if the medical officer of health shall cease to hold office before the thirty-first day of December in any year, he shall make the like report for so much of the year as shall have expired when he ceases to hold office.

15. He shall give immediate information to Us of any outbreak of dangerous epidemic disease within the district, and shall transmit to Us a copy of each annual report and of any special report. He shall make a special report to Us of the grounds of any advice which he may give to the sanitary authority with a view to their requiring the closure of any school or schools, in pursuance of the code of regulations approved by the Education Department, and for the time-being in force.

16. At the same time that he gives information to Us of an outbreak of infectious disease, or transmits to Us a copy of his annual report, or of any special report, he shall give the like information or transmit a copy of such report to the County Council or County Councils of the county or counties within which his district may be situated.

17. In matters not specifically provided for in this order, he shall observe and execute any instructions issued by Us, and the lawful orders and directions of the sanitary authority applicable to his office.

18. Whenever we shall make regulations for all or any of the purposes specified in Section 134 of the Public Health Act, 1875, and shall declare the regulations so made to be in force within any area comprising the whole or any part of the district, he shall observe such regulations, so far as the same relate to or concern his office.

The duties of a medical officer of health to a port sanitary authority, prescribed by the Local Government Board, are very similar to the above except that references to inspection of food, offensive trades, and schools are omitted, and "ships" are substituted for "houses." The following embrace the distinctive features of the Order :—

He shall inform himself as far as practicable respecting all conditions affecting or threatening to affect injuriously the health of crews and other persons on ship-board within the district. . . . He shall inquire into and ascertain by such means as are at his disposal the causes, origin, and distribution of diseases in the ships and other vessels within the district, and ascertain to what extent the same have depended on conditions capable of removal or mitigation. . . . He shall, by inspection of the shipping in the district, keep himself informed of the condition injurious to health existing therein. . . . On receiving information of the arrival within the district of any ship having any infectious or epidemic disease of a dangerous character on board, or of the outbreak of any such disease on board any ship within

the district, he shall visit the vessel without delay, and inquire into the causes and circumstances of such outbreak, and advise the persons competent to act as to the measures which may appear to him to be required to prevent the extension of the disease, and so far as he may be lawfully authorised, to assist in the execution of the same. . . . On receiving information from the inspector of nuisances that his intervention is required in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a ship, he shall, as early as practicable, take such steps authorised by the Public Health Act, 1875, on that behalf, as the circumstances of the case may justify and require . . . also when any vessel within his district has had dangerous infectious disease on board, he shall give notice thereof to the medical officer of health of any port in the United Kingdom whither such vessel is about to sail.

For the efficient and conscientious discharge of these duties, it is evident that a medical officer of health must make himself thoroughly acquainted with the fundamental principles of public and practical hygiene, with the general and local circumstances which may affect the health of the population in his district, and with the various clauses of the Public Health and other sanitary Acts which more immediately concern his office. (See previous Chapter.) So much is left to his discretionary power in advising the sanitary authority, and in certifying as to what is or is not injurious to the public health, that he cannot but feel the grave responsibility which will devolve upon him if, through ignorance or neglect on the one hand, or through mistaken zeal and want of tact on the other, he fails to carry out his duties honestly, judiciously, and efficiently.

To those who are new to the duties, and who have received no practical training under an experienced medical officer of health, some brief details and suggestions under the following headings may be of service :—

1. *Natural Conditions affecting the Public Health.*—These comprise the geological and topographical features of a district, and climate. Official information as regards geological characteristics may be obtained from the geological maps of the Ordnance Survey and the special sections published by the Surveyor-General; while fuller details could be readily collected from local sources. In most districts

there will generally be found some one who has made the geology of the locality a special study.

The topographical conditions relate to the situation of the various parts of the town or district, whether low-lying, elevated, or sloping. A good map showing the boundaries of the district, and its subdivisions, whether into parishes, hamlets, etc., is essential. Maps of towns should show the course of main sewers and water-mains, and also the divisions of the town into wards or sub-districts. Such maps are exceedingly useful, because they can be utilised as spot maps to illustrate the distribution of disease, or the incidence of mortality.

Except in the case of public water-supplies whose sources are at a distance, the quantity and quality of the obtainable water-supply in a district will depend very much on the two previous sets of conditions. So also will the nature of the subsoil, and the facilities for drainage and sewerage. All this, however, has been fully explained in previous parts of this work. (See Chapters VII. X. and XII.)

Attention should also be directed to the meteorological conditions of the district, such as the daily temperature and rainfall, the force and direction of winds, the barometric pressure, and the degree of humidity. In most large towns these observations are carefully recorded, and where this is the case, the health officer should endeavour to obtain, through the sanitary authority, the record of the observations weekly. In districts where no such observations are made, it will be no part of his duty to supply this information, but at the same time it is necessary that he should take cognisance of meteorological fluctuations, because they constitute very important factors of health or disease in every district. (See Chapter VI.)

2. *Dwellings and Premises.*—So far as possible the sanitary condition of every house in the district, as well as its surroundings, should be inquired into. Of course systematic inspection of this description can only be carried out by the sanitary inspectors, and in towns it can only be done in sections; but the medical officer of health should

not only carefully scrutinise the record-books in which the details are entered, but should make himself thoroughly acquainted with the sanitary condition of, at all events, the worst class of property, so that he may be in a position to advise and report.

In carrying out systematic inspection in rural districts, it is advisable that the inspector should complete the survey of one or more parishes or villages before submitting the details to the medical officer of health, who would then appoint a day or days for going over the survey with the inspector. The tabulated forms to be used for such a survey will vary slightly according as the district is urban or rural, and the several columns may be arranged under the following headings:—

Number; date of inspection; situation and description of premises; names of occupier and owner; number of sleeping-rooms, and inmates; nature, situation, and condition of closet-accommodation; nature of water-supply; defects in drainage, ventilation, or general condition of premises; existence of any special source of actual or possible nuisance; additional observations.

All houses which are deemed to be unfit for human occupation, or which, though unoccupied, appear to be in a dangerous condition, should be carefully noted for the inspection of the medical officer of health, who is bound to report them under the Housing of the Working Classes Act, 1890.

In towns, common lodging-houses, tenement houses, back-to-back houses, cellar-dwellings, and houses huddled together in narrow courts and alleys, should receive particular attention, and in all districts schools should be frequently visited.

3. *Factories, Workshops, Bake-houses, Slaughter-houses, Cow-sheds, Dairies, etc.* should be kept under constant supervision, and the medical officer of health should assure himself that the bye-laws and regulations applying to all of these are properly carried out. The chief industries of the district, and offensive trades, should also be inquired into, and their effects noted as regards the health of the persons employed, smoke, or other nuisance, and river pollution.

4. *Water-Supply.*—In districts where the water-supply is public, the medical officer of health should make himself

acquainted with the quality of the water, amount per head, and the risks of pollution, both as regards the source of supply and the mode of distribution; the nature of the supply, whether constant or intermittent; the relation between mains and closets; the situation and condition of cisterns; the separation of cisterns for domestic supply from those supplying closets; the situation of overflow pipes, and the like, are all points which should receive careful attention. In rural districts, the sufficiency of the water-supply, as well as its quality, the situation of wells, and the risks of pollution, should all be duly noted, and samples of suspicious well-water should be examined. In villages where the water-supply is insufficient, it will become a question for the medical officer of health to advise generally as to how this want may best be remedied,—whether by providing one or more public wells, by carrying out a proper water-scheme, by compelling neighbouring owners of property to unite in providing a sufficient supply under the Public Health (Water) Act, by storage of the rainfall in isolated cases, or by carting water into the village to meet special emergencies, leaving of course all practical details to be dealt with by the sanitary engineer, surveyor, or sanitary inspector. (Chapters VII. and VIII.)

5. *Drainage, Sewerage, etc.*—In towns, full information with regard to these conditions, as well as the treatment and disposal of the sewage, will be obtained from the borough engineer or town surveyor. Special attention should be given to the ventilation and flushing of sewers, and the condition of house-drains as regards ventilation, flushing, freedom from smell, and construction; while the efficiency of the sanitary fittings, the disconnection of waste-pipes, and, as far as possible, the severance of all direct communication of house-drains with sewers, are additional points of importance which should not escape notice. In rural districts, it will devolve upon the medical officer of health to report as to whether the drainage of particular villages is satisfactory, and to recommend or not, as he may

think fit, as to whether a competent engineer should be called in to survey and prepare plans.

6. *Scavenging.* — In towns, personal inspection as to whether the scavenging is properly and systematically carried out should be made periodically, and in rural districts the medical officer of health will have to inquire and decide as to whether public scavenging has become necessary for increasing villages or localities.

7. *Routine of Duty and other Details of Work.*—In large urban or metropolitan districts, the medical officer of health is provided with an office, at which he should attend at stated hours every morning, in order that he may meet the sanitary inspectors, read their reports of the previous day's work, examine their diaries and other books, and give them instructions for the day. Often there is a large amount of correspondence, and as regards this, all letters should be stamped with date of receipt and filed, and all official letters sent out should be copied in a book and indexed. He himself must keep a diary, and with clerical assistance he should also keep a complaint book, inspection books, notification of diseases book, and tables for classification of birth and death returns. He should also appoint a stated hour in order that he may be interviewed by ratepayers, or any one preferring a complaint. In addition to office work, there will be periodical and special inspections, inquiries, attendance at meetings, and giving evidence in legal proceedings.

In respect to small urban and rural districts, it may be said that as almost all the medical officers of health of such districts are engaged in private practice, the duties do not partake of a routine character, and the efficient discharge of them must occasionally be rendered somewhat difficult. But every such officer should keep a diary and inspection book, attend punctually to correspondence, and tabulate his returns regularly. As regards his medical brethren, he must be especially careful to observe the ethics of the profession, and act up to the golden rule, "Do to others as you would be done by." Indeed, all health officers, whether

private practitioners or not, should guard against visiting any cases of infectious disease without the consent of the medical attendant, and always if possible when he is present; nor, unless under very exceptional circumstances, should any action be taken for the removal of a patient to hospital without his concurrence. It is no part of the routine duty of any medical officer of health, unless he is a port officer, to visit cases of infectious disease, and the diagnosis of the attendant should never be questioned unless there are the strongest and most obvious reasons for doing so, which should always be frankly stated. A medical officer of health should endeavour to be on friendly terms with all his medical brethren, and never hesitate to court their assistance or advice when he feels he may require them in the discharge of his duties. It need hardly be said that all such favours should be readily and ungrudgingly reciprocated on his part.

8. *Legal Proceedings.*—Unless under very exceptional circumstances, the medical officer of health should never conduct a case before the justices,—that is the duty of the clerk to the sanitary authority, or in respect to common nuisances it is often discharged by the sanitary inspector. Although he will often have to recommend that proceedings be taken, his duty, so far as the prosecution is concerned, should be confined to furnishing a certificate, or giving evidence when required. With well-trained inspectors, it is seldom that he will be required to give evidence except as regards dilapidated dwellings, cases of overcrowding, infected houses, or exposure of infected persons, clothing, etc., unsound meat, nuisances which are likely to be contested, and offensive trades.

9. *Official Conduct.*—In large urban districts, the medical officer of health should always endeavour to encourage an *esprit de corps* in his staff of inspectors, not doing their work, although he is legally empowered to act as an inspector, but by proper supervision and inspection assuring himself that they discharge their duties efficiently and with tact. He should listen courteously to any remarks or

suggestions which they may make, and if they are trained officers, give them credit for knowing their duties as well as he does his own. If, unfortunately, he should deem it necessary to report any serious delinquency or neglect of duty on their part, he should always frankly commend those who perform their duties satisfactorily. In many small districts this subordination of the sanitary inspector to the medical officer of health is not observed, indeed the relationship is often reversed, but for such reversed relationship the medical officer of health has only himself to blame.

As regards the portion of the community committed to his charge, he should endeavour, conscientiously and to the best of his ability, to fulfil his obligations towards them, and, if in practice, he should in no wise shirk his public duty even at the risk of losing his best patient.

His relations to the sanitary authority or sanitary committee, as the case may be, should be guided by common sense and a sense of duty. He should always remember that he is their servant and sanitary adviser, not their dictator; and at their meetings he should carefully avoid taking part in discussions on his reports, unless called upon to do so, or in reply to objections. He should attend all meetings at which his presence is requested or expected; and when he does attend, he should support his views, when called upon, with clearness, firmness, courtesy, and tact. His proposals may be rejected, but if they do not lie within the scope of the statutory enactments requiring their enforcement, he should never resent opposition, but again bring them forward on future occasions. But with regard to breaches of sanitary law, which in spite of his representations may be persistently ignored, he should unhesitatingly point out the obligations which devolve upon the authority, and, failing action, he can always appeal to the Local Government Board by forwarding a copy of any special report which he may deem it necessary to submit to the authority in the first instance. After he has submitted any recommendations, the responsibilities rest on the sanitary authority, not on him. Under all circumstances, however,

he should strive to exercise a wise forbearance when he can conscientiously do so, and on all occasions maintain a courteous, dignified, and friendly demeanour towards the sanitary authority, feeling assured that tact and good temper, like good words, "are worth much, and cost but little."

10. *Statistical Returns and other Sources of Information.*—In addition to obtaining a full knowledge of the natural and artificial conditions which affect the health of the population, the medical officer of health should also make himself thoroughly acquainted with the health-history of his district. By referring to the more recent quarterly and annual reports of the Registrar-General, the abstracts of the Boards of Guardians, and the reports which have already appeared with regard to the health of the district, he will obtain all the statistical data representing its vital history for the past few years, as indicated by the number of the population, its rate of increase, the birth-rate, the marriage-rate, the rate of mortality, the prevalency of endemic, epidemic, or other specially fatal diseases, the death-rate at different ages, the amount of pauper sickness, etc. From the last census returns, again, he will obtain much useful information as regards the areas, houses, and population, and the ages, civil condition, and occupation of the people; and at a census period he should endeavour to obtain, with the consent of the Registrar-General, full particulars regarding each "enumeration district" for permanent use and reference.

The district-registrars throughout the country are instructed by the Registrar-General to forward the returns of births and deaths to medical officers of health, and are allowed 2d. per entry for remuneration, which the sanitary authority is empowered by the Local Government to pay. The sanitary authority also supplies the blank forms, and defrays the expense of postage. Except as regards deaths from fever or other infectious disease, a return of which should be forwarded immediately, the usual returns of the registrar should be forwarded to the medical officer of health at the close of every week. Blank forms may be

obtained from Messrs. Knight and Co., publishers, Fleet Street, London; Messrs. Shaw and Sons, Fetter Lane, London; Messrs. Farrant and Frost, Merthyr-Tydfil, and other publishers, or they may be printed by order of the sanitary authority, according to a form drawn up by the medical officer of health himself. (See Appendix.)

If the district is a large urban one, the deaths may be classified according to sub-districts or streets; and if it be a large rural one, they may be classified according to sub-districts or parishes. In large urban districts, the classification should be that used by the Registrar-General, or the classification drawn up by the Society of Medical Officers of Health, but in small urban or rural districts it is by no means necessary to compile elaborate tables, and the classification which is required for the annual report to the Local Government Board will answer all practical purposes. For the sake of comparison it is much to be regretted that some uniform system of classification is not enforced in all districts, a simple system for rural and small urban districts, and a more elaborate system for urban districts containing say 25,000 inhabitants and upwards. In many districts, too, there is some chance of confusion arising from the fact that the registration sub-districts are frequently not conterminous with the several sanitary districts, inasmuch as small urban districts generally form part of a registration sub-district, the other part being included in a neighbouring rural sanitary district. Deaths of non-residents should be distinguished in the returns, and returns should also be obtained of deaths of persons belonging to the district which occur in institutions outside the district. (See Chapter XVIII.)

By an order of the Local Government Board, dated February 1879, all district and workhouse medical officers, appointed after 28th February of that year, are required to furnish the medical officer of health with returns of pauper sickness and deaths, and to notify cases of infectious disease. In districts where the Infectious Diseases (Notification) Act is not in force, these returns supply useful and timely in-

formation, but where the Act is in force, they are of very little value. Cases of dangerous infectious disease, occurring in canal boats or in common lodging-houses, must be reported to the medical officer of health, whether the Notification Act is in force or not, and sanitary authorities are empowered to make bye-laws requiring notification of such diseases in tenement lodging-houses, vans, and tents.

All cases of dangerous infectious disease which are notified or come under the knowledge of the medical officer of health should be tabulated according to streets, sub-districts, or parishes, in the same way as the deaths, while cases removed to hospital must be classified separately. Spot maps are exceedingly useful for indicating at a glance the incidence of infectious disease in large towns. Further, all cases of dangerous infectious disease which are notified, or come under the cognisance of the medical officer of health, should forthwith be notified to the teachers whom they concern in different parts of the district, and in towns to all head teachers.

In addition to the digest of sanitary law given in the previous chapter, the volume on *Sanitary Law* (No. III.) of the *Treatise on Public Health*, edited by Stevenson and Murphy, and Lumley's *Public Health Acts*, from both of which much of the previous chapter has been collated, will be found to be very useful for reference; and to these may be added Glen's *Sanitary Orders* of the Local Government Board, and Knight's *Annotated Model Bye-Laws*. Where local Acts are in force, the provisions applying to public health questions must, of course, be well studied; while an intimate acquaintance with the bye-laws and regulations in force in the district is also essential.

11. *Reports.*—All special reports from the medical officer of health to the sanitary authority should be concise and to the point. For large towns the stated reports, weekly, monthly, or quarterly, must necessarily be of a somewhat stereotyped character, because they will deal mainly with the vital statistics and incidence of disease during the period under review. As a model of the plan in which weekly

reports may be arranged, the following headings may be quoted of the weekly health return which Dr. Tatham, now Superintendent of Statistics, issued when medical officer of health for Manchester :—

(1) Meteorology, sickness, and condition of the public health.
(2) Notification and local distribution of cases of infectious sickness.
(3) Hospital isolation of patients suffering from infectious diseases.
(4) Comparative statistics of births and deaths in recent weekly returns.
(5) Local distribution of deaths in registration sub-districts. Pauperism—weekly number of persons relieved by the guardians.
(6) Register of sanitary work done during the week.
(7) Notifications to school authorities of cases of dangerous infectious disease.

Apart from this weekly return, Dr. Tatham made it a rule to issue spot maps, indicating the incidence of dangerous infectious disease, to all the free libraries throughout the city.

Special reports on special subjects, copies of which must be forwarded to the Local Government Board, should always be submitted separately, and not as parts of brief periodical reports. If they appear in the newspapers of the district, as will generally be the case, the medical officer of health should endeavour, without being diffuse, to make them readable and instructive, and especially so when he considers it necessary to address the public through this channel. Although he will find the press to be of great service in educating the public on sanitary matters, it need hardly be said that he should avoid entering into controversy.

Although the annual report is the only report which is rendered obligatory by the Order of the Local Government Board, it is advisable, even for the smaller urban and rural districts, to submit quarterly reports, because they not only serve to keep up the general interest in the health of the district, but they greatly facilitate the preparation of the annual report, which should be based on the instructions conveyed in the following Memorandum issued by the Local Government Board. It will be observed that reference is

made in the Memorandum to different sections of the Order already quoted (see p. 731), and the statistical tables alluded to are the Tables A and B given in the Appendix.

After pointing out that all annual reports should be forwarded to the Local Government Board within six weeks after the close of the year, or if not forwarded within that period, that the Board should be informed as to the reason of the delay, the Memorandum proceeds as follows :—

The report should be chiefly concerned with the conditions affecting health in the district and with the means for improving those conditions. It should consider these subjects with reference to the past and future as well as to the particular year, and the account of the sanitary state of the district generally should, while marking the point that has been reached in the sanitary state and administration of the district, indicate directions for further consideration and action. The sanitary history of the year under review should include a record alike of the proceedings of the medical officer of health himself and of the proceedings taken under his direction or advice. And the tabular statements of sickness and mortality in the district during the year, to be made on the forms supplied for the purpose, should be the subject of comment in the text of the report, in so far as deductions from them may assist the sanitary authority to an appreciation of the lines of action needful in the future.

The medical officer of health, in reporting his proceedings and advice, will find it advantageous to follow, in the main, the order in which the subject-matters of his duty appear in the several paragraphs of Article 18, and herein special care should be taken in reporting on the influences affecting or threatening to affect injuriously the public health within the district, and causes, origin, and distribution of disease within the district, may usefully be the subjects of annual record ; and an account be given both of the actual circumstances of the time, and also of any improvement or deterioration that has occurred during the past year in conditions conducive to health or to disease. For example, a vigilant health officer has in his annual report opportunity for stating and restating facts as to water-supplies and house construction, conditions of storage and of removal of excremental and other refuse customary in the district; together with facts as to the adequacy or inadequacy of isolation and disinfection in the district, and the like. And such a health officer, reporting on the diseases and their causes within the district, will generally have some instructive details to give, either of conditions newly productive of disease, or of matters that have been remedied with advantage to the public health. In reporting upon Section 3, not only the fact of having made systematic inspections, but the outcome from those inspections, should be duly put on

record. They are inspections independent of such inquiries as, under other articles of the Order, the medical officer of health has to make into particular outbreaks of disease, or into unwholesome conditions to which his attention may have been specially called by complaints or otherwise ; and will include the house-to-house inspections which may be necessary in particular localities.

Of these inspections, systematic and occasional, and of the judgment he has formed thereon as to the sanitary state of his district, and of the advice he has in consequence given to the sanitary authority and the action taken by the authority thereon, the annual report should contain a full account.

In making such systematic inspection, as in much of his other action, the medical officer of health will usually have required the assistance of the inspector of nuisances ; and it will be for the medical officer to include in his report an account of the action which, at his instance, the inspector may have taken for the removal of nuisances injurious to health.

As regards the tabular statements of sickness and mortality only one observation appears to be needful—the district under the superintendence of a medical officer of health will often contain several parts evidently differing in their circumstances, or having very different rates of mortality, either of mortality from all causes, or of mortality from some particular disease or class of diseases. The observation of these differences can scarcely fail to lead to valuable information, and it is in view of such differences that the tabular statements are required in Section 14 to be classified according to *localities*, and that provision for such a classification is made in the forms supplied for returns of deaths. In the absence of any ascertained differences of the above sort, it will still be desirable to classify the deaths of the district according to the part of the district in which they occur ; and for this purpose any areas of known population (such as parishes, groups of parishes, townships, or wards) may be taken as representing "*localities*" for the purposes of the Order. Classification on this basis will be likely to lead to the discovery of real differences when the returns for several years can be compared together.—The same considerations apply to the records of sickness (Table B). These records should be tabulated for every sanitary district ; and it will be well before proceeding to fill the columns and the blank spaces, to note carefully the headings and the footnotes. These records will have particular interest for districts which have a system of "notification" and which have provided themselves with public means for isolating cases of infectious sickness.

What has been said above with regard to the information which an annual report should contain must be understood, not as suggesting that the report should be limited to these subjects, or that more detailed or differently arranged tabular statements may not be added, but as indicating the sort of information required by the Board's Order.

Many medical officers of health will doubtless, with great advantage to the administration of their district, furnish much more detailed information respecting particular questions to which they have been led by the circumstances of the foregoing year to devote attention, or in the investigation of which they may have arrived at valuable conclusions. Any information of this kind will be appreciated by the Local Government Board.

It will be seen from the above instructions, that the medical officer of health is permitted every latitude as to the order and arrangement of his report; but even in respect to the simplest report it is necessary that he should first tabulate his statistics according to the "localities" or divisions of his district whose death-rates or sickness-rates he may deem it desirable to differentiate, taking care, of course, to eliminate the deaths of persons not belonging to such localities, and to include the deaths of persons belonging to such localities whose deaths are recorded in other districts or localities, such as workhouses, hospitals, etc. Having prepared his tables, and calculated the various rates, such as birth-rates, death-rates, infant-mortality rates, zymotic death-rates, etc., for the whole district and the several localities, and classified the infectious diseases which have been notified or come under his notice in the same way, he is in a position to comment upon all these figures in the body of his report. The report might then be written somewhat in the following order:—

Area, census population, and estimated population.

Geological and topographical features of the district.

Birth-rates, death-rates, etc., and remarks on distribution of deaths throughout the whole of district.

Comparison of birth- and death-rates with those of previous years.

Distribution of cases of infectious disease, with remarks on any special outbreaks.

Precautionary measures adopted, *e.g.* removal to hospital, or need of hospital accommodation, school closure, disinfection, etc.

Results of systematic inspection during the year in respect to—

House accommodation, overcrowding, condition of yards, cleansing, closure of houses, repairs, house drainage, closet accommodation, nuisance removal:

Water-supply—quality, quantity, and fittings, where public supply is provided. In rural districts—condition of public and private wells, scarcity in any particular villages; recommendations:

Sewerage—flushing, ventilation, and repair of sewers; need of extensions or new schemes in villages; disposal and treatment of sewage:

Public scavenging—whether efficiently carried out, or whether in certain villages or growing localities it has become necessary:

Chief industries in relation to health of workers. Smoke or effluvium nuisances, river pollution, etc.:

Burial-grounds—overcrowding of; need for mortuaries:

Bye-laws and regulations in force, or necessity for bye-laws. Whether efficiently carried out in respect to houses, lodging-houses, slaughter-houses, offensive trades, dairies, cow-sheds, and milk-shops, etc.:

Remarks as to the execution of the following Acts:—Factory and Workshops Acts, Alkali Acts, Rivers Pollution Acts, Housing of the Working Classes Act, Canal Boats Acts, Cowsheds, Dairies, and Milkshops Order, etc.:

Legal proceedings taken under the Public Health or other Sanitary Acts during the year, with any remarks as to special cases without mentioning names of persons.

Then might follow classified summary of work done in sanitary inspector's department, and report of surveyor, if any.

The full statistical tables, prepared and arranged as above indicated, should be appended to the report, and only illustrative excerpts of the statistical data appear in the text.

All annual reports should be printed.

Section II.—Duties of Surveyors

Public health owes much to the town surveyor, and Parliament has ill-requited his services by leaving him still

an unprotected officer. The duties which devolve upon him, even in medium-sized towns, necessarily include not only a full knowledge of building and building materials, sanitary fittings, construction of drains and sewers, water-works and water-fittings, and the bye-laws in force; but he must be able to prepare plans and estimates, lay out and repair roads and streets, organise and superintend the scavenging of the town, the cleansing and watering of streets, the flushing of sewers, the disposal of refuse, and the treatment of the town sewage. He has also to act as paymaster to the men under him, and keep a variety of account books, which must always pass the scrutiny of the auditor.

In order to be able to discharge these varied and responsible duties, he must be well acquainted with the details and principles of practical sanitation, and commence his career by serving as an articled pupil in a town-surveyor's office. He should also pass some qualifying examination, such as that of the Sanitary Institute, which will, at all events, be of itself a high recommendation when he applies for an appointment.

Although every urban sanitary authority is compelled under the Public Health Act of 1875, as previously stated, to appoint a surveyor, rural authorities only appoint when they have urban powers conferred on them, and the person appointed is generally the sanitary inspector, who should of course be able to see that building plans are properly prepared and submitted, and that buildings, fittings, drains, etc., are constructed according to the bye-laws. For small rural districts in which few new houses are being erected, the sanitary inspector is occasionally also appointed road-surveyor; and if the inclusive salary is made sufficient, and the condition imposed that the officer should keep a pony and trap, such an arrangement is to be commended, provided the officer is competent, and is bound to devote the whole of his time to his duties.

No orders or instructions have been issued by the Local Government Board in respect to the duties of surveyor,

but every such officer, even of a small district, should make himself well acquainted with *The Annotated Building Bye-Laws*, published by Knight and Company.

Section III.—Duties of Sanitary Inspectors

All sanitary inspectors, part of whose salaries are repaid by county councils, are appointed and hold their appointments under the same conditions as medical officers of health appointed with the approval of the Local Government Board. Although they may be suspended by a resolution of the sanitary authority, they cannot be dismissed from office without the sanction of the Board. In almost all large towns, however, this protection on the part of the Board is not available, and sanitary inspectors are subject to dismissal on notice. In all these cases, the duties will be prescribed by the sanitary authority or their medical officer of health, but every one who desires an appointment as a sanitary inspector will stand a much better chance if he has passed the examination for the certificate granted by the Sanitary Institute, or some other recognised Board of Examiners.

It will be seen from the subjoined regulations that the objectionable title of "inspector of nuisances" is still the legal title for that officer so far as districts outside the metropolis are concerned, but by Section 139 of the Public Health (London) Act, 1891, it is enacted that in future "inspectors of nuisances" are to be designated by the more appropriate title of "sanitary inspectors."

They are also designated sanitary inspectors under the Public Health (Scotland) Act, 1897. In Ireland they are styled "sanitary sub-officers" under the Public Health (Ireland) Act, 1878, and in rural districts the relieving officers are generally appointed to discharge the duties.

Both the Local Government Boards of Scotland and Ireland have issued orders with respect to the duties of the office, which conform in essentials to the following issued by the English Board in March 1891 :—

(1) He shall perform, either under the special directions of the sanitary authority, or (so far as authorised by the sanitary authority) under the directions of the medical officer of health, or in cases where no such directions are required, without such directions, all the duties specially imposed upon an inspector of nuisances by the Public Health Act, 1875, or by any other statute or statutes, or by the orders of the Local Government Board, so far as the same apply to his office.

(2) He shall attend all meetings of the sanitary authority when so required.

(3) He shall by inspection of the district, both systematically at certain periods, and at intervals as occasion may require, keep himself informed in respect of the nuisances existing therein that require abatement.

(4) On receiving notice of the existence of any nuisance within the district, or of the breach of any bye-laws or regulations made by the sanitary authority for the suppression of nuisances, he shall, as early as practicable, visit the spot, and inquire into such alleged nuisance or breach of bye-laws or regulations.

(5) He shall report to the sanitary authority any noxious or offensive businesses, trades, or manufactories established within the district, and the breach or non-observance of any bye-laws or regulations made in respect of the same.

(6) He shall report to the sanitary authority any damage done to any works of water-supply, or other works belonging to them, and also any case of wilful or negligent waste of water supplied by them, or any fouling by gas, filth, or otherwise, of water used for domestic purposes.

(7) He shall from time to time, and forthwith upon complaint, visit and inspect the shops and places kept or used for the preparation or sale of butchers' meat, poultry, fish, fruit, vegetables, corn, bread, flour, milk, or any other article to which the provisions of the Public Health Act, 1875, in this behalf apply, and examine any animal, carcase, meat, poultry, game, flesh, fish, fruit, vegetables, corn, bread, flour, milk, or other article as aforesaid which may be therein; and in case any such article appear to him to be intended for the food of man, and to be unfit for such food, he shall cause the same to be seized, and take such other proceedings as may be necessary in order to have the same dealt with by a justice: provided, that in any case of doubt arising under this clause, he shall report the matter to the medical officer of health, with the view of obtaining his advice thereon.

(8) He shall, when and as directed by the sanitary authority, procure and submit samples of food, drink, or drugs suspected to be adulterated, to be analysed by the analyst appointed under "The Sale of Food and Drugs Act, 1875," and upon receiving a certificate stating that the articles of food, drink, or drugs are adulterated, cause

a complaint to be made, and take the other proceedings prescribed by that Act.

(9) He shall give immediate notice to the medical officer of health of the occurrence within the district of any contagious, infectious, or epidemic disease ; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a house, he shall forthwith inform the medical officer of health thereof.

(10) He shall, subject to the directions of the sanitary authority, attend to the instructions of the medical officer of health with respect to any measures which can be lawfully taken by an inspector of nuisances under the Public Health Act, 1875, or under any other statute or statutes, for preventing the spread of any contagious, infectious, or epidemic disease of a dangerous character.

(11) He shall enter from day to day, in a book to be provided by the sanitary authority, particulars of his inspections and of the action taken by him in the execution of his duties. He shall also keep a book or books, to be provided by the sanitary authority, so arranged as to form, as far as possible, a continuous record of the sanitary condition of each of the premises in respect of which any action has been taken under the Public Health Act, 1875, or under any other statute or statutes, and shall keep any other systematic records that the sanitary authority may require.

(12) He shall at all reasonable times, when applied to by the medical officer of health, produce to him his books, or any of them, and render to him such information as he may be able to furnish with respect to any matter to which the duties of inspector of nuisances relate.

(13) He shall, if directed by the sanitary authority to do so, superintend and see to the due execution of all works which may be undertaken under their direction for the suppression or removal of nuisances within the district.

(14) He shall, if directed by the sanitary authority to do so, act as officer of the said authority as local authority under the Contagious Diseases (Animals) Act, 1886, and any Orders or Regulations made thereunder.

(15) In matters not specifically provided for in this Order, he shall observe and execute all the lawful orders and directions of the sanitary authority, and the Orders of the Local Government Board which may be hereafter issued, applicable to his office.

As regards port sanitary inspectors, the main duties are thus set forth in the order of the Local Government Board issued in 1883 :—

He shall, by inspection of the shipping in the district, keep himself informed in respect of the nuisances existing therein that require abatement under the Public Health Act.

On receiving notice of the existence of any nuisance on board of any ship or other vessel within the district, or of the breach of any bye-laws or regulations made by the port sanitary authority for the suppression of nuisances, he shall, as early as practicable, visit the vessel, and inquire into such alleged nuisance or breach of bye-laws or regulations.

He shall give immediate notice to the medical officer of health of the occurrence within his district of any infectious or epidemic disease of a dangerous character, or of the arrival within the district of any ship or other vessel having such disease on board; and whenever it appears to him that the intervention of such officer is necessary in consequence of the existence of any nuisance injurious to health, or of any overcrowding in a vessel, he shall forthwith inform the medical officer thereof.

It will be seen from these regulations that though the sanitary inspector is not expected, unless so far as authorised by the sanitary authority, to act under the special directions of the medical officer of health, it is very desirable that both officers should act in concert, and keep in touch with each other, even in districts where the health officer is a busy medical practitioner. In the smaller urban districts an office for the inspector is usually provided, where he should attend every morning at a fixed hour to receive complaints and write up his books of record. In rural districts, an office is seldom provided; but for interviews, the inspector should fix a stated hour at which he may be seen at the Union Workhouse before or after each meeting of the Guardians.

The books which he will have to keep will vary according to the character of the district; but they should include —(1) a *Pocket Note-Book* arranged so as to afford spaces for the situation of premises, name of owner and occupier, description of premises, number of sleeping-rooms, number in family, nuisances, sanitary defects, water-supply, etc.; (2) a *Complaint Book*, in which all complaints are recorded; (3) a *Diary*, which should be posted up daily; (4) a *Nuisance Record Book*, in which all nuisances and sanitary defects copied from his note-book are recorded and similarly arranged, with date of notice and abatement of nuisance, whether verbal, by letter, or by legal notice; (5) a *Sanitary Survey*

Book, in which to record particulars of complete surveys of various parts of his district; (6) a *Copying Letter Book*, in which all important letters should be copied; (7) a *Register* for all cases of infectious disease notified, or which come under his notice; and (8) a *Register* and *Inspection Book* for cow-sheds and dairies. In urban districts, he is often expected to keep a book recording his visits to common lodging-houses, and the number of lodgers between stated intervals, and also a book recording his inspection of slaughter-houses. In districts through which canals pass, he will also have to keep a book for the records of his inspections of canal boats, if he is appointed inspector under the Canal Boats Acts. All these books, or such of them as are required, should be procured for him by the clerk of the sanitary authority, together with the books of forms of the various notices required by the Public Health Acts and other Acts.

At meetings of the sanitary authority or sanitary committee, as the case may be, he should always submit his record of nuisance book, which should be gone through and signed by the chairman, and such other books as the authority may desire to see, and when submitting them he may or may not present a brief report stating the number of notices issued since last meeting, the number of nuisances or other defects removed, and other matters. Although no annual report is required by the Local Government Board regulations, he should always prepare an annual summary, which should be included in the health officer's report; and as regards details, these should be drawn up or tabulated on a uniform plan, which will vary according to the character of the district.

As it is upon him far more than on the medical officer of health that a sanitary authority has to rely for the efficient execution of the sanitary Acts in their district, he should always endeavour to carry out his duties systematically; and this can only be effected by regular periodical inspection. If, in a rural district, he is specially called upon to visit a particular village, much time can be saved in

periodical inspection by devoting the day to inspecting the whole or part of that village. It is only by careful inspection that nuisances and other sanitary defects can be discovered and removed, and the more thoroughly this is carried out in the first instance the easier will his duties become. In urban districts, the general health of the community is largely protected by public water-supplies, efficient systems of drainage, proper closet-accommodation, systematic scavenging, and the enforcement of bye-laws; but in rural districts, and in scattered villages, all these safeguards are either altogether lacking, or protective only to a very limited extent. Hence, apart from the nuisances strictly applicable to the dwellings themselves, such as dampness, dilapidations, uncleanliness, or overcrowding, most of the nuisances met with are connected with pig-keeping, defective drains, polluted wells, and, above all, closet-accommodation.

The sanitary defects in and around dwellings have already been described in Chapter XIII. p. 377; the mode of inspection, p. 381; the sources of well-pollution, p. 210; the methods best suited for the removal of nuisances connected with privies, cess-pools, ash-pit middens, etc., p. 301; and the treatment of sewage in rural districts, p. 341; while the special precautions which should be taken to prevent the spread of infectious disease and rules for disinfection have been given in Chapter XVI. p. 539. As regards the important duties of food inspection, the diseases which render the flesh of animals unfit for the food of man have been described in Chapter II. p. 34; the examination of butcher-meat, p. 48; and the examination of fish, vegetables, and other articles of food, p. 53.

For the inspector's duties in respect to food adulteration, see p. 691; cow-sheds and dairies, p. 695; noxious or offensive trades, p. 638; canal boats, p. 663; common lodging-houses, p. 657; and slaughter-houses, p. 651. His duties in respect to various other matters, such as the enforcement of bye-laws, the issuing of notices, and applications for summonses have been fully detailed in the summary of the Public Health Acts and other sanitary Acts in the Chapter on Sanitary Law.

In carrying out these numerous and important duties it is necessary that the inspector should be well acquainted with the various enactments under which his interference is made obligatory, and by which he is empowered to take proceedings, when so authorised by the sanitary authority, but it is by no means desirable that he should be always threatening or invoking the aid of the law. Indeed, an inspector who discharges his duties with tact and discretion will often succeed in procuring the abatement of nuisances and the removal of other sanitary defects by personal interview and by verbal or written notice, far more readily than by issuing the bare legal form of notice without interview or comment. And this applies specially to inspectors in rural and small urban districts, but, as already stated, all notices, however given, should be recorded in the nuisance-book with the dates of notice and abatement. All complaints, whether anonymous or not, should receive personal investigation, and as far as possible they should be treated as privileged, so that the name of the informant, if given, should not be divulged. Such betrayal of confidence is always sure to lead to unpleasantness, which would otherwise be avoided. At the same time he should be careful that he is not made the tool of ill-will or spite, and for that reason alone he should inquire personally into the subject of any complaint made to him. While he is bound to exercise a certain amount of toleration, and give reasonable time for the execution of any structural alterations which are called for, he should have no hesitation in dealing promptly with persons who tacitly ignore, or refuse to comply with, notice; and in these cases he should make application for authority to summon after legal notice has been given. In the discharge of his responsible duties he may expect occasional abuse, but he should always be in the position to be able to take abuse as a compliment, and should it become intolerant or obstructive he can appeal to the authority for legal protection. A judicious officer, however, who is courteous as well as firm, and who discharges his duties without fear or favour, will rarely meet with either abuse or obstruction.

APPENDIX A

Memoranda, Regulations, etc., issued by the Local Government Board

I.—General Memorandum on the Proceedings which are advisable in Places attacked or threatened by Epidemic Disease.

1. Wherever there is prevalence or threatening of cholera, diphtheria, fever, or any other epidemic disease, it is of more than common importance that the statutory powers conferred upon Sanitary Authorities for the protection of the public health should be well exercised by those Authorities, acting with the advice of their Medical Officers of Health.

2. Proper precautions are equally requisite for all classes of society. But it is chiefly with regard to the poorer population, therefore chiefly in the courts and alleys of towns, and at the labourers' cottages of country districts, that local authorities are called upon to exercise vigilance, and to proffer information and advice. Common lodging-houses, and houses which are sub-let in several small holdings, always require particular attention.

3. Wherever there is accumulation, stink, or soakage of house refuse, or of other decaying animal or vegetable matter, the nuisance should as promptly as possible be abated, and precaution should be taken not to let it recur. Especially examination should be made as to the efficient working of sewers and drains, and any defect therein, and any nuisance therefrom or from any foul ditches or ponds, should be got rid of without delay. The ventilation of sewers, the ventilation and trapping of house drains, and the disconnection of cistern overflows and sink-pipes from drains should be carefully seen to. The scavenging of the district, and the state of receptacles for excrement and of ash-pits or dust-bins, will require close attention. In slaughter-houses, and wherever animals are kept, strict cleanliness should be enforced.

4. In the removal of filth during periods of epidemic disease, it is

commonly necessary to employ chemical agents for reducing or removing the offence and harm which may be involved in the disturbance of the filth. In the removal of privy contents these agents are more particularly wanted if the disease in question be cholera or enteric fever. The chemical agent should be used liberally over all exposed surfaces from which filth has been removed. Unpaved earth close to dwellings, if it be sodden with slops or filth, ought to be treated in the same way.

5. Sources of water-supply should be well examined. Water from sources which can be in any way tainted by animal or vegetable refuse, especially those into which there may be any leakage or filtration from sewers, drains, cess-pools, or foul ditches, ought no longer to be drunk. Above all, where the disease is cholera, diarrhœa, or enteric fever, it is essential that no impure water be drunk.

The liability of leaky water-pipes to act as land drains and to receive foul matters as well as land drainage through their leaks is not to be overlooked. And such leaky pipes, running full of water with considerable velocity, are liable to receive, by lateral insuction at their points of leakage, external matters that may be dangerous. This latter fact is not recognised so generally as it should be; and ignorance of it has probably baffled many inquiries in cases where water services have in truth been the means of spreading disease.

If, unfortunately, the only water which for a time can be got should be open to suspicion of dangerous organic impurity, it ought at least to be boiled before it is used for drinking, but then not to be drunk later than 24 hours after it has been boiled. Filtering of the ordinary kind cannot by itself be trusted to purify water. It cannot be too distinctly understood that dangerous qualities of water are not obviated by the addition of wine or spirits.

6. When there appears any probable relation between the distribution of disease and of milk-supplies, the cleanliness of dairies, the purity of the water used in them, the health of the persons employed about them, and the health of the cows that furnish milk should always be carefully investigated. Even apart from any apprehension of milk being concerned in a particular outbreak of disease, it is desirable that English people should adopt the custom, which is always followed in some continental countries, of boiling all milk at once upon its reception into a house.

7. The washing and lime-whiting of uncleanly premises, especially of such as are densely occupied, should be pressed with all practicable despatch.

8. Overcrowding should be prevented. Especially where disease has begun, the sick-room should, as far as possible, be free from persons who are not of use to the patient.

Ample ventilation should be enforced. It should be seen that windows are made to open, and that they are sufficiently opened.

Especially where any kind of infective fever has begun, it is essential, both for patients and for persons who are about them, that the sick-room and the sick-house be constantly traversed by streams of fresh air.

9. The cleanliest domestic habits should be enjoined. Refuse matters should be speedily removed or destroyed; and things which have to be disinfected or cleansed should always be disinfected or cleansed without delay.

10. Special precautions of cleanliness and disinfection are necessary with regard to infective matters discharged from the bodies of the sick. Among discharges which it is proper to treat as infective are those which come in cases of small-pox and scarlatina from the affected skin; in cases of cholera and enteric fever from the intestinal canal; in cases of diphtheria and scarlatina from the nose and throat; likewise, in cases of any eruptive or other epidemic fever, the general exhalations of the sick. The caution which is necessary with regard to such matters must, of course, extend to whatever is imbued with them; so that bedding, clothing, towels, handkerchiefs, and other articles which have been in use by the sick may not become sources of mischief, either in the house to which they belong or in houses to which they are conveyed. So far as articles of this class can be replaced by rags or things of small value, it is best to use such things and burn them when they are soiled. Otherwise clothing and infected articles should be subjected to the disinfectant of the sick-room or be removed for disinfection by heat.

In enteric fever and cholera the evacuations should be regarded as capable of communicating an infectious quality to any nightsoil with which they are mingled in privies, drains, or cess-pools; and after such disinfection of them as is practicable, they should be disposed of without delay and under the safest conditions that local circumstances permit. They should not be thrown into any fixed privy receptacle, and, above all, they must never be cast where they can run or soak into sources of drinking-water.

11. All reasonable care should be taken not to allow infective disease to spread by the unnecessary association of sick with healthy persons. This care is requisite, not only with regard to the sick-house, but likewise with regard to schools and other establishments wherein members of many different households are accustomed to meet.

12. If disease begins in houses where the sick person cannot be properly accommodated and tended, medical advice should be taken as to the propriety of removing him to an infirmary or hospital. Every Sanitary Authority should have in readiness an hospital for the reception of such cases.

Where dangerous conditions of residence cannot be promptly remedied, it will be best that the inmates, while unattacked by disease, remove to some safer lodging.

13. Privation, as predisposing to disease, may require special measures of relief.

14. In certain cases special medical arrangements are necessary. For instance, as cases of cholera in this country sometimes begin somewhat gradually in the comparatively tractable form of what is called "premonitory diarrhœa," it is essential that, where cholera has appeared, arrangements should be made for affording medical relief without delay to persons attacked, even slightly, with looseness of bowels. So, again, where small-pox is the prevailing disease, it is essential that all unvaccinated persons (unless they previously have had small-pox) should very promptly be vaccinated; and that revaccination should be performed in cases properly requiring it.

15. It is always to be desired that the people should, as far as possible, know what real precautions they can take against the disease which threatens them, what vigilance is needful with regard to its early symptoms, and what (if any) special arrangements have been made for giving medical assistance within the district. For the purpose of such information, printed hand-bills or placards may usefully be employed, and in cases where danger is great, house-to-house visitation by discreet and competent persons may be of the utmost service, both in quieting unreasonable alarm and in leading or assisting the less educated and the destitute parts of the population to do what is needful for safety.

16. The present memorandum relates to occasions of emergency. Therefore the measures suggested in it are essentially of an extemporaneous kind; and permanent provisions for securing the public health have, in express terms, been but little insisted on. It is to be remembered, however, that in proportion as a district is habitually well cared for by its Sanitary Authority, the more formidable emergencies of epidemic disease are not likely to arise in it.

17. Provision by the public authority for disinfection by heat of bulky articles, and of those which cannot without injury be exposed to chemical agencies, ought always to be in readiness. Without such provision no complete disinfection can be effected. Partial and nominal disinfection, besides being wasteful, may be mischievous, as giving rise to a false security.

18. The following system of domestic disinfection may be commended to Sanitary Authorities who have already provided adequate public means for the disinfection and for the disposal of infected matters and things:—

(*a*) For the purposes of the sick-room, such as the reception of soiled handkerchiefs, sheets, and the like, as well as for the swabbing of floors, a valuable disinfecting solution may be made with perchloride of mercury. It is well to have this solution slightly acid, coloured also in such a way that it shall not readily be confused with drinks or medicines; and proper caution should be given to avoid accidents in its use. Sanitary

Authorities will find it advantageous to have such a solution[1] prepared under the direct instructions of the Medical Officer of Health, and supplied of a uniform strength at the infected house upon the order of that officer.

(*b*) In places provided with proper systems of excrement disposal, excrements of cholera and enteric fever, after being treated in detail with the same disinfecting solution in ample quantity, may be safely put into the ordinary closet; but special care as to the flushing of drains and sewers, and special frequency in the removal and exchange of excrement receptacles, will commonly be wanted. Where the only closet is one that communicates with a cess-pool or privy pit, the best arrangement for the disposal of infected stools that under these improper local circumstances may be found practicable will have to be adopted.

(*c*) A substance generally available in the removal of filth from privies and ash-pits, and for application to foul earth and the like,[2] is sulphate of iron (green copperas), either in a strong solution made by stirring crystals of the salt with five or ten times their bulk of hot water, or in the form of powder, to which form the crystals may be readily brought after desiccation. This agent should be used in quantity sufficient to destroy all odour, and in the removal of filth accumulations it should be well mixed with successive layers of the matter to be removed. The dry form of application is to be preferred where masses of wet or semi-solid filth have to be dealt with.

(*d*) For disinfection of the air of rooms, after the room has been prepared by the removal of persons, and of such articles as are best disinfected by heat, and by the closing of windows and crevices, sulphurous acid gas in ample quantity may be evolved, the doors being kept closed for six hours or more. The amount of sulphurous acid required for the disinfection of a moderate-sized room can be obtained by burning $1\frac{1}{2}$ lbs. of sulphur (roll brimstone) in a pipkin over a small fire placed in the middle of a room, with an old tray or the like to protect the flooring.

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[1] A solution fitted for the desired purposes may be made with $\frac{1}{2}$ oz. corrosive sublimate, 1 fluid oz. hydrochloric acid, and five grains of commercial aniline blue, in three gallons (a bucketful) of common water. It ought not to cost more than 3d. the bucketful, and should not be further diluted. The use of non-metallic vessels (wooden or earthenware house-tubs or buckets) should be enjoined on those who receive it, and articles that have been soaked in it should be set to soak in common water for some hours before they go to the wash.

[2] The removal of dangerous filth is here the object to be attained. It cannot confidently be stated that either the iron salt or any available substance will effect a true disinfection of such masses of filth as are here in question.

These processes should be effected by skilled persons acting under the directions of the Medical Officer of Health.

(*e*) After measures of disinfecting a room have been taken, all wall paper should be stripped from the walls and be burned, and the room ought to have its ceilings and walls thoroughly washed or lime-whited.

19. For detailed information on disinfection by heat, on hospital accommodation, and on small-pox, and on questions of school administration during the prevalence of infectious disease, see the Office Memoranda and Reports on these subjects.

R. THORNE THORNE,
Medical Officer.

Local Government Board,
Medical Department,
26*th August* 1892.

II.—Regulations as to Cholera, Yellow Fever, and Plague: Ports (9*th November* 1896).

Part I

Art. 1.—In this Order—

The term "Ship" includes vessel or boat.

The term "Officer of Customs" includes any person acting under the authority of the Commissioners of Her Majesty's Customs.

The term "Master," used in relation to a ship, includes the officer, pilot, or other person for the time-being in charge or command of the ship.

The term "Cholera" includes Choleraic Diarrhœa.

The term "Sanitary Authority" means every Port Sanitary Authority, and every Council of a County Borough and every Urban or Rural District Council whose district includes or abuts on any part of a customs port, which part is not within the jurisdiction of a Port Sanitary Authority.

The term "Local Authority" means any Council of a County Borough or any Urban or Rural District Council, and in the Administrative County of London any Sanitary Authority as defined by the Public Health (London) Act, 1891.

The term "Medical Officer of Health" includes any duly qualified Medical Practitioner appointed or employed by a Sanitary Authority to act in the execution of this Order.

The term "Infected" means infected with Cholera, Yellow Fever, or Plague: Provided that every ship shall be deemed infected in which there is or has been during the voyage, or during the stay of such ship in the port of departure or in a port in the course of such voyage, any case of Cholera, Yellow Fever, or Plague.

PART II

Art. 2.—(1) The Officer of Customs who, on the arrival of any ship from foreign, shall visit the ship shall ascertain, so far as possible, whether such ship is infected, and if he have any reason to suspect that the ship is infected or has come from any infected place, shall require the Master of the Ship, or the Surgeon, if the ship carries a Surgeon, to give (in writing under his hand and in the form hereunto appended or in a form to the like effect) a true answer to the following question :—

Question.—Has any case or suspected case of
Cholera,
Yellow Fever, or
Plague
occurred in the ship , of which you are , during the voyage from , or during the stay of the ship in that port or in any other port in the course of the voyage?

Answer.— cases or suspected cases of occurred on board the during the voyage from [*or* during the stay of the ship in the port of].

or

No case or suspected case of Cholera, Yellow Fever, or Plague occurred on board the during the voyage from , or during the stay of the ship in that port or in any other port in the course of the voyage.

Signed——————————,

Master [*or* Surgeon] of the——————————.

(2) The Officer of Customs who, on the arrival of any ship from foreign, shall visit such ship shall, if he find, or have reason to suspect, that the ship is infected, detain such ship, and order the Master forthwith to moor or anchor the same in such position as such Officer of Customs shall direct; and thereupon the Master shall forthwith moor or anchor the ship accordingly.

Art. 3.—Whilst such ship shall be so detained, no person (other than an Officer of Customs or a person acting in the execution of this Order) shall leave the same.

Art. 4.—The Officer of Customs detaining any ship as aforesaid shall forthwith give notice thereof, and of the cause of such detention, to the Sanitary Authority of the place where such ship is lying.

Art. 5.—Such detention by the Officer of Customs shall cease as soon as the ship shall have been duly visited and examined by the

Medical Officer of Health ; or, if the ship shall, upon such examination, be found to be infected, as soon as the same shall be moored or anchored in pursuance of Article 10.

Provided, that if the examination be not commenced within twelve hours after the ship shall have been moored or anchored in pursuance of subdivision 2 of Article 2, the ship shall, on the expiration of the said twelve hours, be released from detention.

Part III

Art. 6.—Every Port Sanitary Authority and every other Sanitary Authority within whose district persons are likely to be landed from ships coming foreign shall, with the approval of the Chief Officer of Customs of the port, fix some place where any ship may be moored or anchored for the purpose of Article 10 ; and shall make provision for the reception of patients and persons suffering from Cholera, Yellow Fever, and Plague, and removed under Articles 13 and 14. The place to be fixed as aforesaid, where any ship may be moored or anchored for the purpose of Article 10, shall be some place within the jurisdiction or district of the Sanitary Authority, unless We otherwise consent ; in which case the place so fixed shall, for the purposes of this Order, be deemed to be within such jurisdiction or district.

Provided that, in the case of any Dockyard Port for which a Queen's Harbour Master has been appointed, the place where any ship shall be moored or anchored for the purpose of Article 10 shall from time to time be fixed by the Port Sanitary Authority with the approval of the Queen's Harbour Master, instead of with that of the Chief Officer of Customs of the Port.

Provided also, that where, in pursuance of the above-cited Order of the Twenty-eighth day of August, One thousand eight hundred and ninety, or of any Order by the said Order revoked, places have been fixed for the mooring or anchoring of ships for the purposes of the regulations by this Order revoked, such places shall be deemed to have been so fixed in pursuance of and for the purposes of this Order.

Art. 7.—The Sanitary Authority, on notice being given to them by an Officer of Customs, under Article 4, shall forthwith cause the ship in regard to which such notice shall have been given, to be visited and examined by their Medical Officer of Health for the purpose of ascertaining whether such ship is infected.

Art. 8.—The Medical Officer of Health, if he have reason to suspect that any ship coming or being within the jurisdiction or district of the Sanitary Authority, whether examined by the Officer of Customs or not, is infected, shall, or, if he have reason to suspect that the ship has come from an infected place, may, visit and examine such ship for the purpose of ascertaining whether such ship is infected ; and may make the like visit and examination in the case of any ship coming or being within the jurisdiction of the Sanitary Authority

which has come from an infected place. The Master of any such ship shall permit the same to be so visited and examined.

The Master of any such ship shall also, on being required so to do by the Medical Officer of Health, cause the ship to be brought to, and, if necessary, moored or anchored in some convenient place while the same shall be visited and examined ; but due regard shall be had to the safety of the ship and to the convenience of navigation.

Art. 9.—If the Medical Officer of Health on making such examination as aforesaid (whether under Article 7 or under Article 8) shall be of opinion that the ship is infected, he shall forthwith give a certificate in duplicate in the following Form, or to the like effect, and shall deliver one copy to the Master, and retain the other copy or transmit it to the Sanitary Authority. He shall also give to Us information as to the arrival of the ship, and such other particulars as We may require.

CERTIFICATE.

_____day of_____, 189 .

_____DISTRICT [*or* TOWN] COUNCIL.

or

_____PORT SANITARY AUTHORITY.

I hereby certify that I have examined the ship of , now lying in the Port of [*or detained at*], and that I find that such ship is infected with [Cholera, *or* Yellow Fever, *or* Plague].

Medical Officer of Health [or Medical Practitioner appointed or employed by the Sanitary Authority].

Art. 10.—The Master of any ship so certified to be infected shall thereupon moor or anchor such ship at the place fixed for that purpose under Article 6, and such ship shall remain there until the requirements of this Order have been duly fulfilled.

Art. 11.—No person (other than an Officer of Customs or a person acting in the execution of this Order) shall leave any such ship until the examination hereinafter mentioned shall have been made.

Art. 12.—The Medical Officer of Health shall, as soon as possible after any such ship has been certified to be infected, examine every person on board the same, and in the case of any person suffering from Cholera, Yellow Fever, or Plague, or from any illness which the Medical Officer suspects may prove to be Cholera, Yellow Fever, or Plague, shall certify accordingly.

Art. 13.—Every person certified by the Medical Officer of Health to be suffering from Cholera, Yellow Fever, or Plague shall be removed, if his condition admit of it, to some hospital or other suitable place appointed for that purpose by the Sanitary Authority; and no person so removed shall leave such hospital or place until the Medical Officer of Health shall have certified that such person is free from the said disease.

If any person so certified to be suffering from Cholera, Yellow Fever, or Plague cannot be removed, the ship shall remain subject, for the purposes of this Order, to the control of the Medical Officer of Health; and such person shall not be removed from or leave the ship, except with the consent in writing of the Medical Officer of Health.

Art. 14.—Any person certified by the Medical Officer of Health to be suffering from any illness which such Officer suspects may prove to be Cholera, Yellow Fever, or Plague, may either be detained on board the ship for any period not exceeding two days, or be taken to some hospital or other suitable place appointed for that purpose by the Sanitary Authority, and detained there, for a like period, in order that it may be ascertained whether the illness is or is not Cholera, Yellow Fever, or Plague.

If any such person, while so detained, shall be certified by the Medical Officer of Health to be suffering from Cholera, Yellow Fever, or Plague the provisions of Article 13 shall apply.

Art. 15.—No person on board such a ship as is mentioned in Article 12 who has not been certified as required by that Article shall be permitted to land unless he satisfy the Medical Officer as to his name, intended place of destination, and intended address at such place.

Such name, intended place of destination, and address shall forthwith be given by the Medical Officer of Health to the Clerk to the Sanitary Authority, and such Clerk shall thereupon transmit the same to the Local Authority of the District in which such intended place of destination is situate.

Every such person who, within forty-eight hours after landing, shall arrive at any place of destination or address other than such place or address as aforesaid, shall forthwith upon such arrival notify in writing his place of destination and address to the Medical Officer of Health of the Sanitary Authority, or to the Local Authority, of the District in which such place is situate.

Art. 16.—The Medical Officer of Health shall, in the case of every ship certified to be infected, give directions, and take such steps as may appear to him to be necessary, for preventing the spread of infection, and the Master of the said ship shall forthwith carry into execution such directions as shall be so given to him.

Art. 17.—In the event of any death from Cholera, Yellow Fever, or Plague taking place on board such ship while detained under Article 10, the Master shall, as directed by the Sanitary Authority or

the Medical Officer of Health, either cause the dead body to be taken out to sea, and committed to the deep, properly loaded to prevent its rising, or shall deliver it into the charge of the said Authority, who shall thereupon cause the same to be otherwise lawfully and properly disposed of.

Art. 18.—The Master shall cause the clothing and bedding and other articles of personal use likely to retain infection which have been used by any person who may have suffered from Cholera, Yellow Fever, or Plague on board such ship, or who, having left such ship, shall have suffered from Cholera, Yellow Fever, or Plague during the stay of such ship in any Port, to be disinfected or destroyed; and if the Master shall have neglected to do so before the ship arrives in port, he shall forthwith, upon the direction of the Sanitary Authority or the Medical Officer of Health, cause the same to be disinfected or destroyed, as the case may require; and if the said Master neglect to comply with such direction within a reasonable time, the Sanitary Authority shall cause the same to be carried into execution.

Art. 19.—The Master shall cause the ship to be disinfected, and every article therein, other than those last described, which may probably be infected, to be disinfected or destroyed, according to the directions of the Medical Officer of Health.

Art. 20.—Where a ship is not ascertained, or certified to be infected, but has passengers on board who are in a filthy or otherwise unwholesome condition, or has come from a place infected with Cholera, Yellow Fever, or Plague, the Medical Officer of Health may, if in his opinion it is desirable with a view to checking the introduction or spread of Cholera, Yellow Fever, or Plague, give a certificate in duplicate in the following form, or to the like effect, and shall deliver one to the Master, and retain the other or transmit it to the Sanitary Authority:—

CERTIFICATE.

_____day of_____, 189__.

_____.

_____DISTRICT [*or* TOWN] COUNCIL.

or

_____PORT SANITARY AUTHORITY.

I hereby certify that I have examined the ship
from , now in the port of ,
and that such ship has passengers on board in a filthy or otherwise unwholesome condition [*or* has come from an infected place], and that, in my opinion, it is desirable with a view to checking the introduction or spread of Cholera, Yellow Fever, or Plague, that the persons on

board such ship should not be allowed to land unless they satisfy me as to their names, places of destination, and addresses at such places.

Signed_____,

Medical Officer of Health (or Medical Practitioner appointed or employed by the Sanitary Authority).

Art. 21.—When such certificate has been given, no person on board the ship shall leave or be allowed to leave the same unless he satisfy the Medical Officer of Health as to his name, intended place of destination, and intended address at such place; and such name, intended place of destination, and address shall forthwith be given by the Medical Officer of Health to the Clerk to the Sanitary Authority, and such Clerk shall thereupon transmit the same to the Local Authority of the district in which such intended place of destination is situate. Every such person who, within forty-eight hours after landing, shall arrive at any place of destination or address other than such place or address as aforesaid shall, forthwith upon such arrival, notify in writing his place of destination and address to the Medical Officer of Health of the Sanitary Authority or to the Local Authority of the district in which such place is situate.

Art. 22.—If the Medical Officer of Health have reason to believe that any ship coming or being within the jurisdiction of the Sanitary Authority is infected, or has come from an infected place, he may direct all bilge water and water ballast to be pumped out in some suitable place before such ship enters any dock or basin:

Provided that, in every case where there may be reasonable cause to apprehend that the ship may be endangered by the removal of the water ballast, the Medical Officer of Health may cause any tank or other receptacle containing the water ballast to be sealed, and thenceforward, so long as the ship remains within the jurisdiction of the Sanitary Authority, no person shall without the permission of the Medical Officer of Health break or remove such seal, or discharge or remove from such tank or receptacle any part of the water ballast.

On the Sanitary Authority providing a proper supply of water for drinking and cooking purposes for persons on board any such ship, the Medical Officer of Health may direct all casks or tanks on board the ship containing water for the use of such persons to be emptied and cleansed, and the Master shall cause the said direction to be carried into effect

Art. 23.—The Master of any ship, or any other person, shall answer truly all such questions put to him by and give all such information to any Officer of Customs or Medical Officer of Health as may be necessary for any purpose of this Order; and no person who is required in pursuance of this Order to give to the Medical Officer of Health or to notify to any Local Authority the name, and intended place of destination and address of such person, shall knowingly give

or notify a false or fictitious name, place of destination or address, or refuse to give or notify as aforesaid the true name, intended place of destination and address of such person.

Art. 24.—The Sanitary Authority may appoint one or more legally qualified medical practitioners to act in the execution of this Order, either in place of or as an assistant or assistants to the Medical Officer of Health, and may pay such practitioner or practitioners reasonable remuneration for his or their services.

Part IV

Art. 25.—The Master of every ship infected with Cholera, Yellow Fever, or Plague shall, when within three miles of the coast of any part of England or Wales, cause to be hoisted at the masthead, or where best seen, a large flag of yellow and black, borne quarterly, and shall keep the same displayed during the whole of the time between sunrise and sunset, and no person (other than an Officer of Customs or a person acting in the execution of this Order) shall leave such ship until after such visit of the Officer of Customs as is mentioned in Article 2, or until after the visit of the Medical Officer of Health in pursuance of Article 8.

Part V

Art. 26.—Nothing in this Order shall render liable to detention, disinfection, or destruction any article forming part of any mail (other than a parcel mail) conveyed under the authority of the Postmaster General, or of the postal administration of any Foreign Government, or shall prejudicially affect the delivery in due course of any such mail (other than a parcel mail) to the Post Office in accordance with the provisions of the Post Office Acts.

Given under the Seal of Office of the Local Government Board, this Ninth day of November, in the year One thousand eight hundred and ninety-six.

Notice.—The Public Health Act, 1896, provides by Sub-section (3) of Section 1 that if any person wilfully neglects or refuses to obey or carry out, or obstructs the execution of, any regulation made under Section one hundred and thirty of the Public Health Act, 1875, or in pursuance of that section as extended to London by the Public Health (London) Act, 1891, and as amended by the Public Health Act, 1896, he shall be liable to a penalty not exceeding one hundred pounds, and in the case of a continuing offence to a further penalty not exceeding fifty pounds for every day during which the offence continues.

III.—Memorandum on the Circumstances under which the Closing of Public Elementary Schools or the Exclusion therefrom of particular Children may be required in order to prevent the Spread of Disease.

1. It is attempted in these notes to bring together the information in the possession of the Local Government Board, derived from the reports of the Board's own Medical Inspectors and of local Medical Officers of Health, respecting school-closure and exclusion from school as precautions against infection, with a view to indicate the best means of preventing the spread of disease by school children among their fellows, while avoiding any unnecessary interruption of the work of education.

2. In the Code of Regulations approved by the Lords of the Committee of Council on Education, the following Article (Art. 88) prescribes, as one of the general conditions required to be fulfilled by a Public Elementary School in order to obtain an annual Parliamentary grant, that—

"The managers must at once comply with any notice of the sanitary authority of the district in which the school is situated, or any two members thereof, acting on the advice of the Medical Officer of Health, requiring them for a specified time, with a view to preventing the spread of disease, or any danger to health likely to arise from the condition of the school, either to close the school, or to exclude any scholars from attendance, but after complying they may appeal to the Department if they consider the notice to be unreasonable."

Article 83 (*a*) prescribes that "if a school has been closed during the year under medical authority, or for any unavoidable cause, a corresponding reduction is made from the number of meetings" (400 a year) required.

Article 101* provides that where the Education Department "are satisfied that by reason of a notice of the Sanitary Authority under Article 88, or any provision of an Act of Parliament, requiring the exclusion of certain children, or by reason of the exclusion under medical advice of children from infected houses, the average attendance has been seriously diminished, and that consequently a loss of annual grant would, but for this Article, be incurred, the Department have power to make a special grant not exceeding the amount of such loss in addition to the ordinary grant."

3. The diseases for the prevention of which school closure, or the exclusion of particular children, will be required are principally those which spread by infection directly from person to person, such as diphtheria, scarlet fever, measles, whooping-cough, epidemic influenza, small-pox, and rötheln. More rarely, the same questions arise in

connection with enteric fever and diarrhœal diseases, which spread not so much by direct infection from person to person as indirectly through the agency of local conditions, such as infected school privies.

4. It will be seen that Article 88 quoted above confers upon Sanitary Authorities an alternative power with respect to public elementary schools.

(A) To cause particular scholars to be for a specified time excluded from attendance, or

(B) To require the school to be closed for a specified time.

5. *A. First, as to exclusion from school of particular scholars.*—Here it will be convenient to consider the circumstances under which the requirements of the public health will be satisfied by the less severe measure of the exclusion from school of particular children.

(*a*) It may be laid down as a universal principle that all children suffering from any dangerous infectious disorder (*i.e.* of a nature dangerous to some of the persons attacked by it, however mild in other cases) should be excluded from school until there is reason to believe that they have ceased to be in an infectious condition (*see* Section 126 of the Public Health Act, 1875).

(*b*) Furthermore, as it is rarely possible to provide effectual separation of the sick from the healthy within the homes of children of the class attending public elementary schools, it must commonly be necessary that all children of an infected household should be excluded from school; first, because otherwise such children might attend school while suffering from the disease in a latent form, or at an unrecognised stage, and, secondly, because it is known that infection may attach itself to, and be conveyed by, the clothes of a person living in an infected atmosphere, even though the person himself remain unaffected. The same considerations will sometimes make it desirable to prohibit the attendance at school of all children from a particular street or hamlet.

In the case of infectious diseases involving little or no danger to life, such as mumps or skin diseases, school interests may be more particularly considered. In such case, however, it will usually be well for the Medical Officer of Health to advise the managers to prohibit the attendance of every child while in an infectious state.

6. *B. Secondly, as to the closing of schools.*—This, by more seriously interfering with the educational work of a district, is a much more grave step for a Sanitary Authority to take than to direct the exclusion of particular scholars. It is a measure that seldom ought to be enforced, except under circumstances involving imminent risk of an epidemic, nor even then as a matter of routine nor unless there be a clear prospect of preventing the propagation of disease, such as could not be looked for from less comprehensive action.

The mere fact that in an epidemic many of the sufferers are school children does not necessarily show that the disease was

caught at school; but the school may with probability be regarded as spreading infection if in a large majority of households attacked the first case be a child attending school; and with still greater probability if a number of children living at a distance from one another, and with no circumstances in common, except that they attend the same school, should be simultaneously attacked, and if it can be ascertained that a child or teacher in an infectious state has actually been attending the school.

7. By Article 18 (6) of the Board's Order of 23rd March 1891, the Medical Officer of Health on the occasion of an outbreak of dangerous infectious disease is to advise the persons competent to act as to the measures to be taken to prevent the extension of the disease. If, therefore, he finds that the children of infected households are attending school, he should send notice of the fact to the schoolmaster, and give such advice as appears to him to be necessary with regard to the exclusion of the children from school, and as to the time for which such exclusion should continue.

Where the number of children to be excluded is small, and the schoolmaster acts on the advice of the Medical Officer of Health, it may not be necessary to take formal action under Article 88 of the code; but where the number of children whom it is desirable to exclude from school is such as is likely seriously to diminish the average attendance, or where the advice of the Medical Officer of Health is not followed, and there is danger of the disease spreading by means of the school, notice for the exclusion of the children in question should be made in accordance with the requirements of Article 88.

The attention of school attendance officers and of schoolmasters should also be drawn to the following considerations. Frequently they themselves will obtain the earliest information of the occurrence of infectious disease among scholars, and it is most desirable that such officer or master should without delay communicate the facts to the Medical Officer of Health. Absence of any child from school on the plea that it is suffering under one of the before-mentioned diseases, and absence of several children of one family from school at the same time, no matter what name be given to the complaint that keeps them at home, should be reported to the health officer. In practice it has been found that this notification of absentees has materially aided the local health officer in taking measures for the suppression of infectious disease, to the advantage alike of the district and of the school. Furthermore, schoolmasters may properly be asked to take note, especially when an epidemic threatens or is present, of symptoms occurring in any of their scholars that may indicate the commencement of disease, febrile in nature. Besides heat of skin, such symptoms are shivering, headache, and languor, especially if commencing suddenly, vomiting, rashes on the skin, and sore throat. When scarlet fever or diphtheria is about,

every trace of sore throat should be looked upon as suspicious. In any case where such symptoms are observed, the safest course will be to exclude the child from school until assurance can be had that it may attend school without harm to itself or danger to other scholars.

8. As regards duration of exclusion from school of particular children, the time to be specified will vary in different diseases and different cases, and in this matter the Sanitary Authority will doubtless be guided by the advice of their Medical Officer of Health.

Medical officers of health, having to specify a time during which any scholars are to be excluded from attendance at any school, should have regard as far as practicable to the circumstances of the particular scholars suffering from infectious disease or living in infected households. Not only the nature of the infection and the length of illness, but the environments of the individual as affecting the retention of infection will deserve consideration. The period of exclusion, for example, will need to be different according to the conditions of a patient's lodgment, according to the sufficiency of the separation that can be effected between a patient and excluded scholars, and according to the opportunities of effectual disinfection that can be afforded to the household. Thus a hard-and-fast rule, such as has been laid down in some districts where scarlatina has been present, that no child shall go to school from an infected house for three months after the disease has begun in that house, is not to be commended. It is indeed possible that under the circumstances of a particular household, a child convalescent from scarlatina or living in the same house with convalescents should not in the interests of other children be permitted to return to school until after so long a period as this; but the same ought not to be assumed of all households in the district that may be invaded by scarlatina. The better plan would be for the Sanitary Authority to secure, during a shorter period, the exclusion of individual sick persons and their housemates from school; and when that period is about to expire, to cause fresh inquiry to be made as to the expediency of further exclusion, and, if found requisite in particular cases, to cause fresh notice to be given to the school managers.

9. In deciding whether an outbreak of infectious disease among children of school age may be best combated by closing the school, or whether it will suffice to exclude the children of infected households, the two most important points to be considered are :—

(*a*) The completeness and promptness of the information received by the officers of the Sanitary Authority respecting the occurrence of infectious cases.

(*b*) The opportunities which exist for intercourse between the children of different households elsewhere than at school.

10. (*a*) The more prompt and full the knowledge of cases of in-

fectious disease that the Sanitary Authority are able to obtain, the better will be the prospect of checking such disease by keeping away from school the children of infected households, and the less will be the necessity for closing schools.[1] If the cases be few in number, and their origin known, the exclusion from school of the children of infected households will probably suffice, but this measure will fail where there are many undiscovered or unrecognised cases, or where the known centres of infection are very numerous.

Commonly, the failure of carefully considered measures of exclusion to stay the spread of an epidemic which shows a special incidence upon school children, may be regarded as pointing to the continued attendance at school of children with the prevalent disease in a mild or unrecognised form, and a strong case will appear for the closing of schools.

If by reason of the absence or exclusion of a large number of children, the attendance at a school be greatly reduced, it may be found better to close it altogether. This is especially apt to occur in the case of epidemics of measles, a disease which is very infectious in the early stages, before the characteristic rash has appeared, and while the symptoms resemble those of a common cold.

11. (*b*) The second material consideration, in deciding as to the desirability of closing schools during the prevalence of infectious disease, is the amount of opportunity for intercommunication between the members of different households elsewhere than at school. In sparsely populated rural districts, where the children of different households, or of separate hamlets, rarely meet except at, or on their way to, the village school, the closing of the school is likely to be effectual in checking the spread of disease. It is less likely to be useful in a town or compact village (particularly where houses are sub-let and yards are in common), where the children of different households when not at school spend their time in playing together, and often run in and out of each other's houses. But it must be remembered that children when at play out of doors are brought into much less close association with each other than when in school.

In rural districts, where epidemic diseases are less frequently prevalent, school closing may be required as an exceptional measure to meet an exceptional state of things. As regards more populous places, it must not be forgotten that if schools were to be closed whenever an infectious disease was prevalent, there are many places where schools would hardly ever be open.

> It will sometimes be necessary to close a school for a day or two to allow of the rectification of sanitary defects of a nature to extend disease, or in order that the school may be disinfected or purified. It has happened that infectious sickness in the master's

[1] Information obtainable under the Infectious Disease (Notification) Act, 1889, will be especially useful in this direction.

family has forbidden the attendance of scholars. These more temporary and occasional closures of schools are contemplated in the Education Code, and are to be regarded as having a real importance of their own.

12. In places where there are several public elementary schools, if an outbreak of infectious disease be confined to the scholars of one particular school, it may be sufficient to close that school only. But where different schools have all appeared to aid in the spread of disease (though perhaps to an unequal extent), the Sanitary Authority may consider it advisable that all should be closed, lest children in an infectious state, who previously attended the schools that are closed, should be sent to others that might remain open.

It must be remembered that Sanitary Authorities have no power in respect of Sunday Schools, or other private schools: except in so far as these may contravene Section 91 (5), Section 126, or other provision of the Public Health Act, 1875; but it will often be expedient to invite the co-operation of managers of such schools in efforts for securing the public health. Experience shows that they are usually ready to defer to the representations of the Authority responsible for the public health of the district.

13. Reports to Sanitary Authorities, advising the closure of a school or schools in any district, are to be treated as "special" reports within the meaning of the General Order of the Local Government Board of 23rd March 1891, and copies of them are required by Article 18 (15) and (16) of that Order to be sent to the Board, and to the County Council. These reports should state the grounds upon which the Medical Officer of Health advocates the closure of the school or schools in preference to the exclusion of particular scholars.

14. All notices of the Sanitary Authority for the closing of Public Elementary Schools should be addressed in writing to the Managers, and should state the grounds on which the closing is deemed necessary.

All such notices shall specify a definite time during which the school is to remain closed; this should be as short a period as can be regarded as sufficing on sanitary grounds, since a second notice may be given before the expiration of the first, if it should be found necessary to postpone the reopening of a school. The Managers of schools, after complying with the requirements of the Sanitary Authority, have the right of appeal to the Education Department, if they consider any notice to be unreasonable.

July 1897. RICH. THORNE THORNE.

IV.—Instructions for Vaccinators under Contract, as prescribed by Orders of the Local Government Board, dated 28th February 1887 and 7th January 1897.

(1) Except so far as any immediate danger of small-pox may require, vaccinate only subjects who are in good health. As regards infants, ascertain that there is not any febrile state, nor any irritation of the bowels, nor any unhealthy state of skin; especially no chafing or eczema behind the ears, or in the groin, or elsewhere in folds of skin. Do not, except of necessity, vaccinate in cases where there has been recent exposure to the infection of measles or scarlatina, nor where erysipelas is prevailing in or about the place of residence.

(2) In all ordinary cases of primary vaccination, make such insertions of lymph as will produce at least four separate good-sized vesicles or groups of vesicles, not less than half an inch from one another. The total area of vesiculation on the same day in the week following the vaccination should not be less than half a square inch.

(3) Direct that care be taken for keeping the vesicles uninjured during their progress, and for avoiding afterwards the premature removal of the crusts. Do not use any needless means of "protection" or of "dressing" to a vaccinated arm; but if, in a particular case, you find reason for means of "protection" or of "dressing" define the material and the manner of use of the appliance best adapted to the case, avoiding all such as cannot readily be destroyed and replaced whenever they become soiled.

(4) Enter all cases in your Register on the day when you vaccinate them, and with all particulars required in the Register up to and including the column headed "Initials of persons performing the operation." Enter the results on the day of inspection. Each of these entries must be attested by the initials of the person who inspects the case. In cases of primary vaccination, register as "successful" only those cases in which the normal vaccine vesicle has been produced; in cases of revaccination, register as "successful" only those cases in which either vesicles, normal or modified, or papules surrounded by areolæ, have resulted. When any operation (whether vaccination or revaccination) has to be repeated owing to want of success in the first instance, it should be entered as a fresh case in the Register.

(5) Endeavour to maintain in your district such a succession of cases as will enable you to vaccinate with liquid lymph directly from arm to arm at each of your contract attendances. When stored lymph, whether humanised lymph or calf lymph, is used, it should be preserved either *dry* on ivory points, thickly charged and constantly well protected from damp; or *liquid* in tubes, hermetically sealed at both extremities. With all stored lymph caution is necessary, lest in time it have become inert, or otherwise unfit for use.

(6) Consider yourself strictly responsible for the quality of whatever lymph you use or furnish for vaccination. In storing lymph, be careful to keep separate the charges obtained from different subjects, and to affix to each set of charges the name, or the number in your Register, of the subject from whom the lymph was derived. Keep such note of all supplies of lymph, whether humanised lymph or calf lymph, which you use or furnish as will always enable you to identify the origin of the lymph. Do not employ lymph supplied by any person who does not keep exact record of its source.

(7) Never take lymph from cases of revaccination. Take lymph only from subjects who are in good health, and, as far as you can ascertain, of healthy parentage; preferring children whose families are known to you, and who have elder brothers or sisters of undoubted healthiness. Always carefully examine the subject as to any existing skin disease, and especially as to any signs of hereditary syphilis. Do not take lymph from children who have any sort of sore at or about the anus. Take lymph only from well characterised uninjured vesicles. Take it at the stage when the vesicles are fully formed and plump. Do not take it from a vesicle around which there is any conspicuous commencement of areola. Open the vesicles with scrupulous care to avoid drawing blood. Take no lymph which, as it issues from the vesicle, is not perfectly clear and transparent or which is thin and watery. From a well-formed vesicle of ordinary size, do not, except under circumstances of necessity, take more lymph than will suffice for the immediate vaccination of five subjects, or for the charging of seven ivory points, or for the filling of three capillary tubes; and from larger or smaller vesicles, take only in like proportion to their size. Never squeeze or scrape or drain any vesicle, and do not use lymph that has run down the skin. Be careful never to transfer blood from the subject you vaccinate to the subject from whom you take lymph.

(8) Scrupulously observe in your inspections every sign which tests the efficiency and purity of your lymph. Note any case wherein the vaccine vesicle is unduly hastened or otherwise irregular in its development, or wherein any undue local irritation arises; and if similar results ensue in other cases vaccinated with the same lymph, desist at once from employing it. Consider that your lymph ought to be changed, if your cases, at the usual time of inspection, on the day week after vaccination, show any conspicuous areolæ round their vesicles.

(9) Keep in good condition the lancets or other instruments which you use for vaccinating, and do not use them for any other purpose whatever. When you vaccinate, have water and a napkin at your side, with which invariably to cleanse your instrument after one operation before proceeding to another. Never use an ivory point or capillary tube a second time either for the conveyance or for the storage of lymph; but when points or tubes have once been charged

with lymph and put to their proper use, do not fail to break or otherwise destroy them.

N.B.—Supplies of lymph are furnished to medical practitioners on personal application at the Office of the Local Government Board, Whitehall, London, between the hours of 12 and 2; or by letter addressed as follows:—

To

The Secretary,
Local Government Board,
Whitehall,
London, S.W.

National Vaccine
Establishment.

APPENDIX B

I.—SYMBOLS AND ATOMIC WEIGHTS OF THE COMMONER ELEMENTARY BODIES

Name.	Symbol.	Combining Weight.
Aluminium	Al	27·5
Antimony	Sb	122
Arsenic	As	75
Barium	Ba	137
Bismuth	Bi	210
Bromine	Br	80
Calcium	Ca	40
Carbon	C	12
Chlorine	Cl	35·5
Chromium	Cr	52·5
Copper (Cuprum)	Cu	63·4
Gold (Aurum)	Au	196
Hydrogen	H	1
Iodine	I	127
Iron (Ferrum)	Fe	56
Lead (Plumbum)	Pb	207
Magnesium	Mg	24
Manganese	Mn	55
Mercury (Hydrargyrum)	Hg	200
Nitrogen	N	14
Oxygen	O	16
Phosphorus	P	31
Platinum	Pt	197·1
Potassium (Kalium)	K	39·1
Silicon	Si	28
Silver (Argentum)	Ag	108
Sodium (Natrium)	Na	23
Sulphur	S	32
Tin (Stannum)	Sn	118
Zinc	Zn	65

II.—ENGLISH MEASURES.

a. *Long Measure.*

Inches.					
12 =	1 Foot.				
36 =	3 =	1 Yard.			
72 =	6 =	2 =	1 Fathom.		
198 =	16·5 =	5·5 =	2·75 =	1 Perch.	
7920 =	660 =	220 =	110 =	40 =	1 Furlong.
63360 =	5280 =	1760 =	880 =	320 =	8 = 1 Mile.

b. *Land Measure.*

Inches.		
7·92 =	1 Link.	
792 =	100 =	1 Chain.
63360 =	8000 =	80 = 1 Mile.

c. *Nautical Measure.*

Knots.

1 = 6075·6 Feet (or 6080 Feet, Admiralty).
3 = 1 League.
60 = 1 Degree = 69·04 English Miles.
A Cable's length = 607·56 feet = $\frac{1}{10}$th of a Sea Mile.

d. *Square Measure.*

Inches.					
144 =	1 Foot.				
1296 =	9 =	1 Yard.			
39204 =	272·25 =	30·25 =	1 Perch.		
1568160 =	10890 =	1210 =	40 =	1 Rood.	
6272640 =	43560 =	4840 =	160 =	4 =	1 Acre.

640 Acres = 1 Square Mile.

e. *Land Measure (Square).*

Links.		
625 =	1 Perch.	
10000 =	1 Chain.	
25000 =	2·5 =	1 Rood.
100000 =	10 =	4 = 1 Acre.

f. *Capacity.*

		Cubic Inches.		
1 Pint	=	34·66	1 Gallon	= 10 lbs. water at 62° Fahr.
1 Quart	=	69·318	1 Cubic Foot	= 6·232 gallons.
1 Gallon	=	277·274	224 Gallons	= 1 ton.

g. *Weight.*

1 oz. = 437·5 grains.
1 lb. = 16 oz. = 7000 grains.
1 gallon of water = 70,000 ,,

III.—COMPARISON OF METRICAL WITH ENGLISH MEASURES.

a. *Weight.*

		Grains.
1 Milligramme	=	0·015
1 Centigramme	=	0·154
1 Decigramme	=	1·543
1 Gramme	=	15·432
1 Kilogramme	=	15432·348
	=	2·2 lbs. (Avoir.)
	=	35·3 oz.

b. *Capacity.*

		Cubic Inches.
1 Cubic Centimetre	=	0·061
1 Litre	=	61·027

1 Cub. Inch = 16·386 Cub. Cent.
1 Fluid Oz. = 28·35 ,, ,,
1 Gallon = 4·543 Litres.
1 Cubic Foot = 28·2 ,,

c. *Length.*

1 Metre	=	39·37 Inches.
1 Decimetre	=	3·94 ,,
1 Centimetre	=	0·39 ,,
1 Millimetre	=	0·039 ,,
1 Kilometre	=	1094 Yards.

d. *Area.*

1 Square Metre = 10·76 sq. ft.
1 ,, Centimetre = 0·154 sq. in.
1 ,, Millimetre = 0·0015 ,,
1 ,, Kilometre = 247 acres.
1 Hectare = 2·47 ,,

IV.—TABLE FOR CONVERSION OF ANALYTICAL RESULTS.

As 1 gallon of water weighs 70,000 grains, therefore—

To convert parts per 1,000,000 (=mgr. per litre) into grs. per gal. multiply by 0·07.

To convert parts per 100,000 into grains per gallon, multiply by 0·7.

To convert grains per gallon into parts per 1,000,000, multiply by 14·3.

V.—TEMPERATURE AND PRESSURE.

$$\frac{(100°)\ \text{Centigrade}}{5} = \frac{(80°)\ \text{Réaumur}}{4} = \frac{(212°)\ \text{Fahrenheit} - 32}{9}$$

To convert degrees Centigrade or Réaumur into degrees Fahrenheit, or *vice versa*, the following are the formulæ to be used :—

$$F = \frac{9C}{5} + 32,\quad F = \frac{9R}{4} + 32$$

$$C = \frac{5(F-32)}{9},\quad R = \frac{4(F-32)}{9}.$$

$$5R = 4C.$$

Thus—

Cent.		Fah.		Réaum.
85°	=	185°	=	68°
35°	=	95°	=	28°
16°	=	60·8°	=	12·8°
etc.		etc.		etc.

	Centigrade.	Réaumur.	Fahrenheit.
Water freezes at	0·0	0·0	32·0
Water, maximum density at .	4·0	3·2	39·2
Water boils at	100·0	80·0	212·0

Standard barometric pressure = 760 millimetres = 29·922 cubic inches.
30 inches = 762 ,,
29·5 ,, = 749 ,,
29 ,, = 737 ,,

Air and all gases expand equally when heated through the same number of degrees of temperature, viz. $\frac{1}{273}$ or 0·00366 of their volume for every degree Centigrade, and $\frac{1}{491}$ or 0·00203 for every degree Fahrenheit; or, expressed generally, according to Charles's law:—The volume of a gas is directly proportioned to its actual temperature reckoned from zero. Thus, one litre of air at 0°C. will become $1+(0{\cdot}00366t)$ litre at any given temperature t, and 1 cubic foot of air at 32° Fahr. will become $1+[0{\cdot}00203\,(t-32)]$ cubic foot at any given temperature t above 32° Fahr.

Boyle's law affirms that the temperature remaining the same, the volume of a gas is inversely proportional to its pressure. As both these laws must be taken into account in reducing volumes of air to standard conditions of temperature and pressure, it is generally convenient to make these two corrections by adopting a single formula, thus:—

$$V=\frac{V'\times P}{760\,[1+(0{\cdot}00366t)]}\ (\text{Cent}),$$

or

$$V=\frac{V'\times P}{760\,[1+(0{\cdot}002\times t-32^\circ)]}\ (\text{Fahr.})$$

Where V = volume of air required under standard conditions of temperature and pressure
V' = observed volume of air,
P = observed pressure mm.
and t = observed temperature, Cent. or Fahr.

VI.—RAINFALL

1 cubic foot of water = 6·232 gallons,
1 inch rain per square yard amounts to 4·673 gallons, and 1 inch falling on a square acre = 101 tons = 22,624 gallons.

The following table by W. Sowerby Wallis, F.M.S., shows the daily yield of water from a roof with varying rainfalls:—

Area of House, 10 feet by 20 feet, or 200 square feet.					
Mean Rainfall.	Loss from Evaporation.	Requisite capacity of Tank.	Mean daily yield of Water.	Mean daily yield of Water in wettest year.	Mean daily yield of Water in driest year.
inches.	per cent.	cubic feet.	gallons.	gallons.	gallons.
20	25	100	4·3	6·7	3·2
25	20	135	5·7	7·5	3·9
30	20	145	6·8	9·4	4·5
35	20	155	7·9	11·0	5·0
40	15	165	9·7	13·1	7·2
45	15	170	10·9	14·2	8·6

For any other size of roof or amount of rainfall, the numbers will be proportional. (See also p. 185.)

For the storage of water in reservoirs in catchment basins, Hawksley's formula is as follows:—$D = \frac{1000}{\sqrt{F}}$, where F = mean annual rainfall in inches, and D = number of days' supply to be stored. To allow for evaporation, the mean annual rainfall is taken as $\frac{5}{6}$ of the average annual rainfall. Thus, with a mean annual rainfall of 25 inches, the number of days' supply would be $\frac{1000}{\sqrt{25}} = 200$.

VII.—ENGINEERING MEMORANDA, FORMULÆ, AND PROBLEMS

1. *Air and Ventilation:*—The velocity acquired by a body falling *in vacuo* to the earth's surface by the force of gravity is 32·18 feet per second, and is generally represented as g. The velocity, therefore, bears a constant relation to this accelerating force and the height through which the body has fallen, and is expressed in the following rule, known as Montgolfier's, that the velocity in feet per second of falling bodies is equal to nearly eight times the square root of the height through which they have fallen, or $V = \sqrt{2gH}$ where H represents the height of the descent. This formula may be varied thus:—

$$V = \sqrt{2g} \times \sqrt{H}, \text{ and } \sqrt{2g} = \sqrt{64 \cdot 36} = 8 \cdot 025 \text{ nearly.}$$

Therefore $V = 8 \cdot 025\sqrt{H}$, or, using 8 as a constant, $V = 8\sqrt{H}$.

In applying this formula to problems of ventilation, H under ordinary conditions of temperature and pressure is about 5 miles or 26,400 feet, because the pressure of the atmosphere on the earth's surface is equal to a column of mercury of 29·92 inches, and as mercury is about 10,500 times heavier than air, this is equal to about 26,400 feet. Air, therefore, rushes into a vacuum with a velocity equal to that which a body would acquire in falling from a height of 26,400 feet or $V = 8\sqrt{26,400}$, or about 13,000 feet per second.

If, however, the air under pressure P passes not into a vacuum but into a space containing air under a lower pressure p, the velocity becomes dependent upon the difference between P and p, and in ventilation problems this difference is represented by the difference between the temperatures of the outside and inside air.

For example, if it is required to determine the theoretical velocity of a current of air in a vertical flue which acts as the outlet for the warmed inside air, and that there is an inlet for the colder outside air, it is evident that the current of warmed air up the flue or shaft is determined by the height of the flue, and the difference between the outside and inside temperatures. The barometric pressure may be discarded because it operates equally at the top of the flue and on the entering air. If, then, h = height of the flue, t' = outside temperature, and t = inside temperature, and as 0·002 represents the

co-efficient of expansion for every degree Fahrenheit, the formula becomes

$$V = 8\sqrt{h \times (t - t') \times 0{\cdot}002}.$$

V, the linear velocity in feet per second, multiplied by the sectional area of the flue or shaft in feet, or decimals of a foot, will give the number of cubic feet of air passing up the flue per second, and therefore the amount of fresh air entering. This theoretical velocity, however, is much influenced by the movements of the outside air, and considerable deductions must be made for friction, varying from $\frac{1}{4}$ to $\frac{1}{2}$, according to the height of the shafts, the number of bends or angles, and the size and shape of inlets and outlets (see *ante*, p. 134).

The theoretical size of inlet and outlet for any required change of air, presuming that the conditions are constant, can be obtained by the following formula, known as De Chaumont's :—

$$\frac{D}{200f\,(\sqrt{h\,(t-t') \times 0{\cdot}002})} = A.$$

Where D = delivery in cubic feet required per hour ; f = co-efficient of friction, h, t, t' = as above ; A = area of inlet or outlet in square inches. 200 is a constant representing the different expressions of time and space, and is obtained thus :—

$$\frac{\text{Seconds (per hour)}}{\text{Square inches (per square foot)}} = \frac{3600}{144} = 25.$$

and $25 \times \sqrt{2g}$ or, the constant, 8 = 200.

To calculate the delivery per hour, the area of outlet being given, the above formula becomes

$$D = 200f(\sqrt{h\,(t-t') \times 0{\cdot}002}) \times A.$$

In mechanical and other ventilation problems, applying more particularly to the ventilation of mines and tunnels, the term "head" is used to represent the weight in pounds of air per square foot required to give a velocity to a column of air, just as in the cases of hot-air flues or furnace shafts it is calculated as the difference in height of two columns of air of equal weight, but of different temperatures.

For warming with hot-water pipes or steam, various formulæ have been devised to calculate the radiating surface, or length and diameter of pipe, for low pressure, high pressure, or steam, required to raise the inside air to varying degrees of temperature from varying degrees of outside temperature. Thus Hood has estimated that the length of 4-inch pipe required to warm 1000 cubic feet of air per minute from a temperature of 16° Fahr. to 60° Fahr. is 176 feet ; from 32° Fahr. to 65° 137 feet ; from 40° to 65° 104 feet ; from 50° to 65° 62 feet ; and so on, in an extended table for varying outside and inside temperatures.

2. *Flow of water.*—The term "head" applied to water in mains or pipes signifies the pressure of a column of water represented by the height of the level of the surface of water in a reservoir or tank above the discharging orifice of the main or pipe connected with such reservoir, tank, or cistern. This pressure in mains or pipes is called the "hydrostatic pressure," in contradistinction to the term "hydraulic pressure," which represents the pressure in flowing water, and is therefore a variable pressure.

What is called "loss of head" applies to the diminished pressure due to friction in pipes or to the lowering of the level of water in a tank or reservoir when the pipes are discharging.

In streams, open channels, or closed channels in which the water is not running full, or, if full, not under pressure, "head" represents the fall, inclination, or gradient in a measured length.

The numerous formulæ prepared by engineers for calculating the velocity of discharge, the quantity per minute, etc., are all based on the formula already given for falling bodies, viz. $V = \sqrt{2gt}$, or $V = 8\sqrt{H}$, where H represents the head of water in feet. But even under the simplest conditions the actual velocity is much less than the theoretical velocity. Thus, suppose the orifice is in a thin plate of an iron cistern containing water, the formula becomes $V = 8\sqrt{H} \times \cdot 615$ (Box).

To find the discharge in gallons from such an orifice the formula is $Q = \sqrt{H} \times D^2 \times 16 \cdot 3$, where Q = gallons discharged per minute, D = diameter of orifice in inches, and H = head of water in feet. With a pipe of considerable length, loss by friction greatly diminishes flow. For instance, a pipe $1\frac{1}{2}$ inches diameter, and 30 feet long, discharges only one-half what a simple orifice of the same diameter would discharge. When running full, the circular pipe discharges a larger quantity than any other form of pipe. To sum up,—the quantity discharged at the outlet of any pipe under pressure depends upon the velocity of flow, and is affected materially by the length and diameter of the pipe, by the number and kind of bends, by the effective head of water, and in a slight degree by the shape of the entry or orifice. In the case of long pipes the effect produced by friction is so very great as to form the chief factor in hydraulic calculations, and numerous formulæ with tables of co-efficients have been prepared by which approximately accurate results may be obtained. For example, Hughes gives the following formulæ :—

Let V = Velocity in feet per second,
D = Diameter of pipe in feet,
H = Inclination of pipe in feet per mile,

then $V = \sqrt{\frac{DH}{2 \cdot 3}}$, $D = \frac{2 \cdot 3V^2}{H}$, and $H = \frac{2 \cdot 3V^2}{D}$.

Example.—Required the velocity of water issuing from a pipe

2 feet in diameter, 4 miles in length, and connecting two reservoirs, one of which is 30 feet above the other.

Here $D=2$, $H=\frac{30}{4}=7{\cdot}5$, or $7{\cdot}5$ feet fall per mile,

therefore $V=\sqrt{\frac{2\times 7{\cdot}5}{2{\cdot}3}}=\sqrt{6{\cdot}52}=2{\cdot}55$ feet per second.

Hurst gives the following formulæ for calculating the flow of water in rivers and open channels :—

$$V=95\sqrt{\frac{A\times F}{P+L}}, \text{ and } Q=A\times V,$$

where A = Sectional area of water-way in square feet,
F = Fall in given length L in feet,
L = Length in feet,
P = Wetted perimeter, or girth of bottom and sides of open channels in feet,
Q = Quantity discharged in cubic feet per second ;
and V = Velocity in feet per second.

In order to estimate the flow of comparatively small water-courses, it is usual to dam up the whole stream, and discharge the water through some artificial channel of known dimensions, such as a long wooden trough, through a sluice, or over a sill or weir. In the first instance the method of calculation is easy because all that is required is to take the velocity by means of a float in feet per second, and the sectional area in square feet, and the product of the two will represent the number of cubic feet discharged per second.

If a sluice is used the method of calculation is roughly as follows :— Multiply area of sluice in square feet by five times the square root of head in feet, and this will give the discharge in cubic feet per minute ; or $Q=A\times 5\sqrt{H}$.

In this instance H is the difference of level of the water above and below the dam, if the sluice is entirely under water, or the height of the level of water in the dam above the centre of the sluice, if the sluice is not under water.

In gauging water flowing over a sill, Molesworth lays down the following rules :—The waste-board must have a thin edge. The height must be measured from the top of the sill, or waste-board, to the level of the surface, where it is not affected by the overfall. The waste-board must have a free overfall. Then, if

H = Height of surface of water above sill in feet,
h = Ditto if measured in inches,
V = Velocity of water approaching the sill in feet *per second*,
C = Cubic feet discharged over each foot width of the sill *per minute*, then

$$\left.\begin{aligned} C &= 214\ \sqrt{H^3} \\ &= 5{\cdot}15\ \sqrt{h^3} \end{aligned}\right\} \text{if the stream above the sill is not in motion,}$$

$$= 214\ \sqrt{H^3+{\cdot}035\ V^2\ H^2} \text{ if in motion.}$$

The following gives the discharge of water over a weir or sill 1 foot in length :—

Depth of fall in inches.	Discharge in cubic feet per minute.
$\frac{1}{2}$	1·70
1	4·82
$1\frac{1}{2}$	8·84
2	13·63
$2\frac{1}{2}$	19·79
3	26·62

3. *Flow of sewage.*—As drains and sewers are intended to convey sewage when only partly full, or, if full, not under pressure, the numerous formulæ devised for calculating the capacity, fall, and delivery have been prepared to meet these conditions. None of them can be deemed to be more than approximate, but the one which is most used for circular sewers is the following :—

$$V = 55\sqrt{D \times 2F}.$$

where D = Hydraulic mean depth,
V = Velocity in feet per minute,
F = Fall in feet per mile,
and 55 = An empirical constant.

What is called the "hydraulic mean depth" is the sectional area of the current of sewage divided by the wetted perimeter. In circular sewers, running full or half full, the hydraulic mean depth is always $\frac{1}{4}$ the diameter or $\frac{1}{2}$ the radius; and for other sectional areas of currents, tables of hydraulic mean depths of circular sewers or drains have been prepared according to various sizes.

Example.—What should be the diameter of a circular drain, with a fall of 64 feet per mile, in order that it may discharge when running full at the rate of three feet per second?

Let X = diameter required,
then F in above formula = 64,
V = 32 feet per second = 180 feet per minute,
and $D = \frac{X}{4}$.

$$\therefore 180 = 55\sqrt{2 \times \frac{X}{4} \times 64} = 55\sqrt{32X},$$

$$\text{or } \frac{180}{55} = \frac{36}{11} = \sqrt{32X},$$

$$\text{and } 32X = \left(\frac{36}{11}\right)^2 = \frac{1296}{121}.$$

$$\therefore X = \frac{1296}{121 \times 32} \text{ feet} = \frac{1296 \times 12}{121 \times 32} = 4 \text{ inches.}$$

Given any two of the three factors in the above formula, the third may readily be found; and if the velocity V is known, the quantity discharged in cubic feet per minute will be represented by VA, where A is the sectional area of the current.

In all sewers the velocity varies as the square root of the fall, and the fall will be proportional to the square root of the velocity.

Example:—A sewer has a fall of 3 inches in 10 feet, with a velocity of 5·5 feet per second, what fall would be necessary to give a velocity of 11 feet per second?

Let X = fall required,
then $5{\cdot}5^2 : 11^2 :: 3$ inches in 10 : X,
$30{\cdot}25 : 121 :: 3$ inches in 10 : X,
$1 : 4 :: 3$ inches in 10 : X,
$\therefore X = 4 \times 3 = 12$ in. in 10 feet, or 1 in 10.

With regard to gradients most suitable for house-drains (see p. 284), and for sewers (p. 290).

The relations of the internal dimensions in an egg-shaped sewer are given by Molesworth as follows:—

Let B = Diameter of bottom of sewer.
C = Diameter of top of sewer.
R = Radius of sides of sewer.
D = Depth of sewer.
$B = \frac{D}{3}$, $C = \frac{2D}{3}$, and R = D.

The special advantage attaching to this form of sewer is, that when the depth of the current is diminished, the wetted perimeter, which is the friction-producing factor, is proportionately reduced instead of being increased as in circular sewers.

APPENDIX C

I.—Suggested Form for Return of Births and Deaths (see page 742).

*.....Sanitary District of ..... Sub-registration District of .....

Return of Births and Deaths for the week ending the .....th day of ..... 189.....

Births { Legitimate, M....., F..... / Illegitimate, M....., F..... } Total ..... Deaths, M....., F..... Total .....

Register No.	Date of Death.	† Residence.	Name and Surname.	Sex.	Age.			Occupation or Calling.	Causes of Death.	By whom Certified.
					Years.	Months.	Days.			

* Insert Urban or Rural.
† Give previous residence of persons dying in public institutions.

Signed ....., *Registrar.*

II.—TABLES A AND B.—NOTE—These two tables are issued by the
is spaced to contain the Statistics

(A)—TABLE OF DEATHS during the year 1897, in the .....

DISEASES, AGES,

Names of Localities adopted for the purpose of these statistics; Public Institutions being shown as separate Localities.	MORTALITY FROM ALL CAUSES AT SUBJOINED AGES.								1	2	3	4
	At all ages.	Under 1 year.	1 and under 5.	5 and under 15.	15 and under 25.	25 and under 65.	65 and upwards.		Small-pox.	Scarlatina.	Diphtheria.	Membranous Croup.
(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)				
								Under 5. ..... 5 upwards.	....	....	....	....
								Under 5. ..... 5 upwards.	....	....	....	....
TOTALS								Under 5. ..... 5 upwards.	....	....	....	....
The subjoined numbers have also to be taken into account												
Deaths occurring outside the district among persons belonging thereto.								Under 5. ..... 5 upwards.	....	....	....	....
Deaths occurring within the district among persons not belonging thereto.								Under 5. ..... 5 upwards.	....	....	....	....

(B)—TABLE OF POPULATION, BIRTHS, AND OF NEW CASES OF
Health, during the year 1897, in the ..... Sanitary District of

Names of Localities adopted for the purpose of these statistics; Public Institutions being shown as separate Localities.	POPULATION AT ALL AGES.		Registered Births.	Age under 5 or over 5.	NEW CASES OF SICKNESS THE KNOWLEDGE OF THE					
					1	2	3	4	5	6
	Census 1891.	Estimated to middle of 1897.			Small-pox.	Scarlatina.	Diphtheria.	Membranous Croup.	Typhus.	Enteric or Typhoid.
(a)	(b)	(c)	(d)	(e)						
				Under 5. ..... 5 upwards.	....	....	....	....	....	....
				Under 5. ..... 5 upwards.	....	....	....	....	....	....
TOTALS				Under 5. ..... 5 upwards.	....	....	....	....	....	....

Local Government Board on separate sheets (see p. 742). Each sheet of Ten Different Localities.

Sanitary District of....., classified according to and LOCALITIES.

MORTALITY FROM SUBJOINED CAUSES, DISTINGUISHING DEATHS OF CHILDREN UNDER FIVE YEARS OF AGE.

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
FEVERS.																	
Typhus.	Enteric or Typhoid.	Continued.	Relapsing.	Puerperal.	Cholera.	Erysipelas.	Measles.	Whooping-Cough.	Diarrhœa and Dysentery.	Rheumatic Fever.	Ague.	Phthisis.	Bronchitis, Pneumonia, and Pleurisy.	Heart Disease.	Injuries.	All other Diseases.	TOTAL.

in judging of the above records of mortality.

INFECTIOUS SICKNESS, coming to the knowledge of the Medical Officer of .....; classified according to DISEASES, AGES, and LOCALITIES.

IN EACH LOCALITY, COMING TO MEDICAL OFFICER OF HEALTH.							NUMBER OF SUCH CASES REMOVED FROM THEIR HOMES IN THE SEVERAL LOCALITIES FOR TREATMENT IN ISOLATION HOSPITAL.												
7	8	9	10	11	12	13	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
FEVERS.											FEVERS.								
Continued.	Relapsing.	Puerperal.	Cholera.	Erysipelas.			Small-pox.	Scarlatina.	Diphtheria.	Membranous Croup.	Typhus.	Enteric or Typhoid.	Continued.	Relapsing.	Puerperal.	Cholera.	Erysipelas.		

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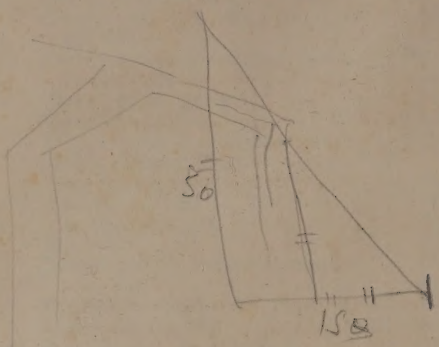

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